

Advanced Information Assurance Handbook

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March 2004

CERT[®]/CC Training and Education Center

Handbook
CMU/SEI-2004-HB-001

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**Carnegie Mellon
Software Engineering Institute**

Pittsburgh, PA 15213-3890

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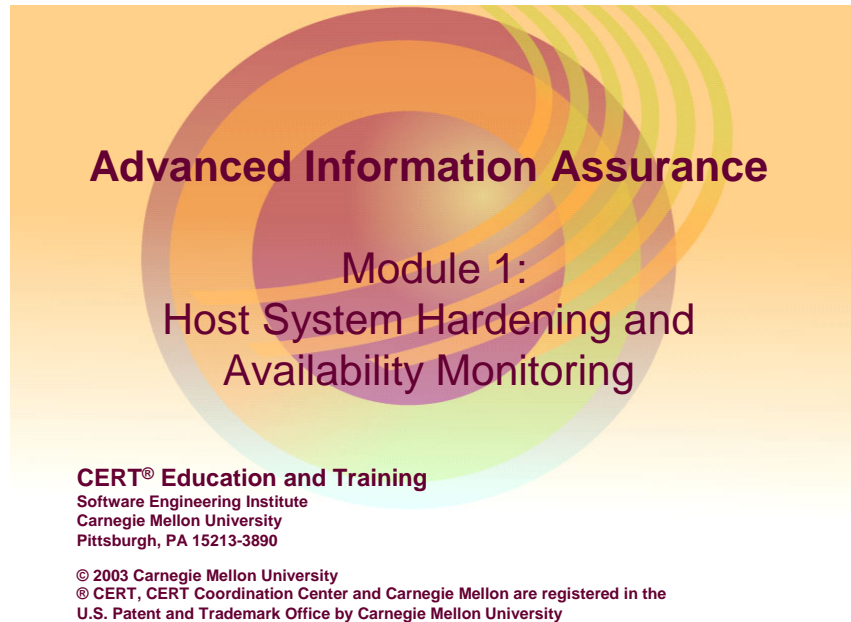
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Abstract

This handbook is for technical staff members charged with administering and securing information systems and networks. The first module briefly reviews some best practices for securing host systems and covers specific techniques for securing Windows 2000 and Red Hat Linux systems. It also discusses the importance of monitoring networked services to make sure they are available to users and briefly introduces two software tools that can be used for monitoring. The second module covers the importance of firewalls and provides instructions for their configuration and deployment. The third module presents the many tasks involved in using an intrusion detection system (IDS) on a network. Topics covered include implementing IDSs on host computers and on networks, using Snort (the most common open-source IDS), and interpreting and using the information gathered using an IDS. The fourth and final module covers real-world skills and techniques for synchronizing the time on networked computers from a central clock, collecting and securing information for forensic analysis, and using a remote, centralized storage point for log data gathered from multiple computers.

1 Host System Hardening and Availability Monitoring



This module briefly reviews some best practices for securing host systems and then covers specific techniques for hardening Windows 2000 and Red Hat Linux systems. It also discusses the importance of conducting service availability monitoring and briefly introduces two software tools for implementing it.



Instructional Objectives

List 5 high-level practices for securing host systems

Use specific scanning tools to determine initial security posture of host systems

Use specific tools to update and patch operating systems and applications

Use specific tools to harden security configurations on host systems

Use specific tools to monitor availability of network systems

1.1 Instructional Objectives

Students will be able to do all of the above upon completion of this module.

Overview

Best practices for hardening host systems

Techniques for hardening Windows 2000 Systems

Techniques for hardening Red Hat Linux Systems

Tools for monitoring the availability of network systems

1.2 Overview

This module will cover the topics outlined above.



Best Practices for Hardening Host Systems

Determine the initial security posture of system (via automated scanning)

Minimize non-essential services, applications, and OS features (Example: Web servers on user systems)

Make sure system has latest patches and hotfixes available

1.3 Best Practices for Hardening Host Systems

The topics covered in slides 4–7 are general security best practices that apply to almost any kind of host system, be it a Windows Web server or a 3Com-managed Ethernet switch. It is important to review these best practices as they provide a framework for the specific hardening techniques that will be discussed later in the module. Host system hardening is one critical component to the “defense in depth” goal. Defense in depth is a strategy in which multiple layers of security measures (technologies, policies, and training) are implemented throughout the network, increasing the overall security posture of the enterprise.

Before you can harden a host system, you must first find out what “state” it’s in from a security standpoint. There are many manual ways of doing this, but using a security scanning tool can help speed up the process. Although a plethora of commercial and open source products are available, they vary in how accurately and effectively they depict the security posture of the system with the results of their scans. The Microsoft Baseline Security Analyzer¹ and the LANguard Network Security Scanner² will be used in this course for scanning our Windows 2000 systems. The Nessus vulnerability scanner will be used to scan our Red Hat Linux systems. These scanning tools will be described in greater detail later in this module.

¹ <http://www.microsoft.com/technet/treeview/default.asp?url=/technet/security/tools/Tools/mbsahome.asp>

² <http://www.gfi.com/downloads/downloads.asp?pid=8&lid=1>

1.3.1 Minimization

The concept of minimization is paramount to the hardening process. Only essential applications and operating system components should be loaded on host systems—especially critical systems like servers. For example, Windows 2000 servers generally should not have Microsoft Office loaded on them, and conversely, Windows XP workstations generally should not have Internet Information Server (IIS) installed. Software vulnerabilities account for a large percentage of the security incidents that occur. Thus, less software on a host generally equates to less exploitation of software vulnerabilities.

1.3.2 Patch Management

Because software bugs are so common, it is essential that host system software be patched effectively. Patch management is a real challenge, especially in very large enterprises. Keep yourself informed about software vulnerabilities that impact your environment and implement procedures for promptly updating your systems with good code. We'll talk about specific techniques and tools later in this module.



Best Practices for Hardening Host Systems - 2

Isolate key services from each other (don't put all your eggs in one basket)

- If resources allow, keep public services on separate hosts
- For redundancy, place multiple essential servers (DNS, domain controllers, etc.) on different physical network segments

1.3.3 Isolation of Services

In conjunction with minimization, isolation of services is also a best practice for security. In production environments, it's best to isolate services (email, www, ftp, file/print, etc.) on separate physical host systems. This way, if a software bug in a given service is exploited by an intruder, the potential impact on other critical services would be limited. Also, if a patch is applied for a specific service (for example, IIS) that requires a reboot of the system, physically isolated services would be unaffected.

1.3.4 Redundant Servers

For some critical services like domain name servers (DNS) and Windows 2000 directory services, it is a good idea to have redundant servers on multiple subnets. This can enhance continuity of service in the event of a network outage.



Best Practices for Hardening Host Systems - 3

Configure for strongest authentication available

- Multi-factor is best (however, plain old username/password can be fairly secure, if proper policies are implemented and enforced)
- Lock down weak default OS/Application settings (Examples: Anonymous enumeration and NTFS permissions on Windows 2000 systems)

1.3.5 Authentication

Authentication is the process of verifying the account credentials (e.g., username and password) of systems or users. It is essentially the gatekeeper for your systems and services, ensuring that only those who have been explicitly permitted are granted access. Because account credentials are so vital, they must be protected. Policies and technologies should be implemented that keep these credentials secure and safe from prying eyes (or packet sniffers)! Additionally, technologies should be implemented that verify the identity of the user (or system) to a degree that's acceptable to the organization. Multi-factor authentication systems are becoming more common; users' identities are verified by validating some combination of something they know (i.e., username and password and/or P.I.N.), something they have (i.e., PKI-enabled smart card), and something they are (i.e., biometrics-based thumbprint scan). Plain old username and password is still the most widely used authentication method and can be relatively secure if password policies (i.e., minimum length, complexity, age) and account lockout policies are enforced.

1.3.6 Changing Weak Default Settings

Many operating systems and applications have some default settings that can open the door to security breaches. For example, an intruder can connect to a specific default share on a Windows 2000 system (IPC\$) and learn a great deal about the system while providing no (in this case null) authentication credentials. It is important to learn about these default weaknesses and change the systems' settings to make them more secure. Administrators should stay current by reading technical security publications and Web sites like <http://www.cert.org>.



Best Practices for Hardening Host Systems - 4

Configure system for logging and auditing

Use host-based firewall to control network access

Use encryption to protect critical data

Ensure physical security of critical host systems

1.3.7 Accountability

The security principle of accountability is a fundamental tenet of defense in depth.

Accountability means that administrators have policies and technologies in place that allow them to understand who is (or was) doing what on a given host system. The most common technological implementation of accountability is accomplished with logging and auditing. Most operating systems have a built-in capability to perform extremely detailed logging and auditing. Unfortunately, much of this capability is disabled by default (especially in the case of Windows 2000). After you've configured logging and auditing on your host systems, it's important to routinely monitor the output—otherwise the value of the implementation is limited. Configuring host systems to push their logs to a centralized collection point (i.e., a syslog server) is a good administrative and security practice.

1.3.8 Controlling Network Traffic

Controlling the network traffic that is permitted into and out of a host system is another security best practice. Implementing host-based firewalls can significantly enhance the security posture of a network because unauthorized network traffic is minimized and can be logged and inspected by administrators.

1.3.9 Backing Up Data

Critical data is almost always more important than the host systems that it resides on. Spending significant resources in hardening your host systems will help protect this data. However, it is also a smart idea to back up data regularly and in some cases ensure its confidentiality by encrypting it. Again, the data is the real asset, not the underlying systems.

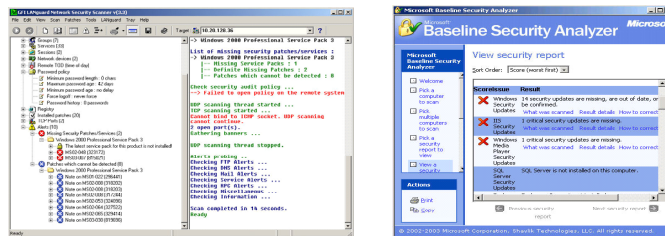
1.3.10 Physical Security

Finally, we would be remiss if we did not mention the importance of physical security. If an intruder gains physical access to a host system, it won't be long before he or she owns and controls that system. Critical host systems like servers and other network infrastructure equipment should be placed in secure facilities where only individuals with privileges (such as administrators) can gain access.

Hardening Windows 2000 Systems

Determine the initial security posture of system

- Microsoft Baseline Security Analyzer (MBSA)
- Languard Network Security Scanner
- GRC.com's Shields Up!!



Demo: Microsoft Baseline Security Analyzer (MBSA)

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Module 1: Host System Hardening and Availability Monitoring – slide 8

1.4 Hardening Windows 2000 Systems

As mentioned previously, there are numerous automated scanning tools available for detecting vulnerabilities in Windows 2000 systems. This class will cover two of these tools, both of them freeware. The slide also mentions Shields Up!!, an HTML-based Internet scanner from GRC.com. This site can be somewhat helpful, as it shows how vulnerable a Windows host is to Internet-based attacks.

1.4.1 Automated Scanning Tools

The Microsoft Baseline Security Analyzer³ (MBSA) is a tool used to streamline identification of security misconfigurations including missing patches and security updates. Scans can be conducted on individual Windows machines or a specified range of machines—local or remote.

The MBSA has command line and graphical interfaces to perform scans on local or remote Windows systems. A scan using this tool will identify configuration problems and vulnerabilities in the following products:

1. Windows NT 4.0/2000/XP
2. Windows Server 2003
3. Internet Information Server (IIS)
4. SQL Server
5. Internet Explorer
6. Office 2000/2002

³ <http://www.microsoft.com/technet/treeview/default.asp?url=/technet/security/tools/Tools/mbsahome.asp>

Scans will also identify missing patches or security updates in the following products:

1. Windows NT 4.0/2000/XP
2. Windows Server 2003
3. Internet Information Server (IIS)
4. SQL Server
5. Internet Explorer
6. Exchange
7. Windows Media Player

The MBSA uses a tool called HFNetChk that scans a machine and checks the patch status by referring to an XML database maintained by Microsoft. The results from the scan will be stored in an XML security report which will be displayed in the graphical user interface (GUI) in HTML.

LANguard Network Security Scanner (NSS)⁴ is a mature vulnerability scanning tool that specializes in uncovering security issues with Windows-based systems—although it is effective on other platforms as well. It has a user friendly GUI and can scan a single system or multiple subnets. It is one of the fastest scanning tools available and has the capability to control and push out Microsoft service packs, patches, and hotfixes to Windows-based systems. Vulnerability scanning features are free; patching capabilities are only active for 30 days with the freeware version. (A license must be purchased to enable permanent patching capabilities.) Care should be taken when scanning hosts with this tool, as it will very likely cause intrusion detection systems to register alerts.

Using the tools mentioned briefly here will give you a fairly good understanding of the security posture of your Windows 2000 systems.

1.4.2 Review Online Information About Windows Vulnerabilities

In addition to using scanning tools, it is also a good idea to review online information about Windows vulnerabilities and hardening. The following are two highly recommended sources:

1. The SANS/FBI Top 20 List, *The Twenty Most Critical Internet Security Vulnerabilities*, [SANS 03] – This regularly updated document offers a good, brief description of problems and suggested hardening approaches.⁵
2. The Microsoft guide *Securing Windows 2000 Server* [Microsoft 03c] – This excellent and very comprehensive guide provides 11 chapters of solid information on hardening Windows 2000 Servers, both as host systems and in their role within an enterprise scenario environment.⁶

⁴ <http://www.gfi.com/downloads/downloads.asp?pid=8&lid=1>

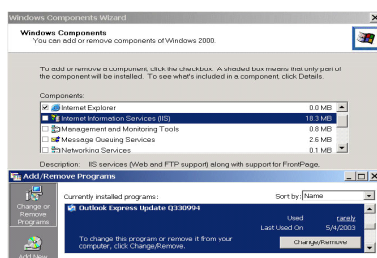
⁵ <http://www.sans.org/top20/top20.pdf>

⁶ <http://www.microsoft.com/technet/treeview/default.asp?url=/technet/security/prodtech/windows/secwin2k/default.asp>

Hardening Windows 2000 Systems - 2

Remove unnecessary OS features and applications

- IIS, Outlook Express, Windows Media Player, Journal Viewer, Games, Posix and OS2 subsystems, etc.
- Primarily concerned with minimizing servers



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Module 1: Host System Hardening and Availability Monitoring – slide 9

1.4.3 Removing Unnecessary Features and Applications

A typical load of Windows 2000 Server (and W2K Professional) has many unnecessary features and applications that should be removed. Depending on the server's role, Internet Information Services (IIS) may or may not be required. IIS, Microsoft's Web and ftp server solution, has become legendary for the number of bugs associated with the software. If your server's role doesn't require IIS, remove it!

Removing Internet Information Services

1. From the Start menu, select Settings > Control Panel > Add/Remove Programs > Add/Remove Windows Components.
2. Uncheck the Internet Information Service box. If your system requires IIS, refer to Harden Internet Information Services (IIS) on page 28 of this workbook.

Windows 2000 Servers should not have any applications designed for entertainment or client-level interaction installed. Follow the above procedure and remove any application of this nature. Examples are games (like Solitaire), Windows Media Player, Journal Viewer, and Netmeeting. Administrators should not be checking their email on production servers, so Outlook Express should be removed as well. Removing Outlook Express is relatively straightforward if Software Installation Services are controlled through Group Policy, but can be rather complicated to remove on a stand-alone server—especially if you follow Microsoft's instructions.

The following procedure is the quickest way to remove Outlook Express from Windows 2000. This is not the Microsoft method; apparently, Microsoft doesn't really want you to

remove Outlook Express at all. Your system must be formatted NTFS. This procedure will also prevent the system file protection feature of Windows from restoring Outlook Express files after they've been deleted.

Removing Outlook Express from Windows 2000 Server (Quick Method)

1. Open Windows Explorer and browse to the folder c:\Program Files\Outlook Express.
2. Right click on that folder and select Properties. Select the Security tab and highlight System in the list of users.
3. Under Permissions, check the Deny box next to Full Access. Click OK. (Click OK again if prompted with a warning message.)
4. Now you can delete the **contents** of the Outlook Express folder. (**Do not** delete the folder itself!)
5. Browse to the folder c:\winnt\system32\dlldata\ and delete the file msimn.exe.
6. From the Start menu, select Settings > Control Panel > Add/Remove Programs > Add/Remove Windows Components. Uncheck the Outlook Express box and then click OK.

That's it. You'll have an empty folder called Outlook Express, but the program will be gone and your system will be that much safer. You may need to repeat this process if you apply a new Service Pack, as it may reinstall the program.

For legacy compatibility reasons, Microsoft built-in support for OS2 and Posix operating systems. The OS2 and Posix subsystems in Windows 2000 can introduce security vulnerabilities to the operating system. Therefore, it is recommended that these subsystems be removed [NSA 03b].

Deleting Subsystem Executables

When deleting subsystem executables, remove the following files from the following folders in this order:

- C:\winnt\system32\dlcache (if present)
 - os2.exe
 - os2ss.exe
 - os2srv.exe
- C:\winnt\system32\
 - os2.exe
 - os2ss.exe
 - os2srv.exe
 - psxss.exe
 - posix.exe
 - psxdll.dll
 - All Files in the \os2 folder, with the exception of the DLL folder and its contents. If the modules in the \DLL folder are removed, functions such as Cmd.exe will fail.

Deleting Subsystem Registry Key Values

Even if the subsystem executables have been removed, the subsystem could be reactivated if related registry keys still exist. In addition to the above files, all registry keys related to the subsystems must be removed.

1. Open the registry editor from the Start menu by selecting Run and typing “Regedt32” in the Run window.
2. Browse to the following key values and remove the entries:

Hive: HKEY_LOCAL_MACHINE

Key: \System\CurrentControlSet\Control\Session Manager\Environment

Name: Os2LibPath

Entry: Delete entry

Hive: HKEY_LOCAL_MACHINE

Key: \System\CurrentControlSet\Control\Session Manager\Subsystems

Name: Optional

Entry: Delete entry

Hive: HKEY_LOCAL_MACHINE

Key: \System\CurrentControlSet\Control\Session Manager\Subsystems

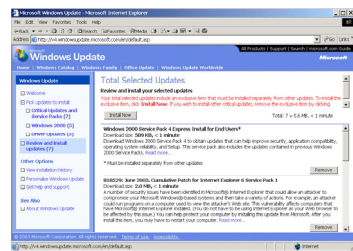
Name: OS2 and POSIX

Entry: Delete entries for both OS2 and POSIX

Hardening Windows 2000 Systems - 3

Solutions for patch management (many—none perfect)

- Windows Update
- Microsoft Software Update Services (SUS)
- Many commercial products (Languard, Shavlik, etc.)



Demo: SUS

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Module 1: Host System Hardening and Availability Monitoring – slide 10

1.4.4 Patch Management

As mentioned previously, patching software bugs in Windows systems is a real challenge. There are many solutions that provide varying levels of capability, but we will discuss only the free solutions available from Microsoft.

Windows Update has been around since Windows 98 and it has been improved over time so that it can update Windows 2000 and XP systems' device drivers and applications, as well as service packs, critical hotfixes, and other patches. It keeps a history of all updates that have been completed on a system and provides for automated and scheduling of downloads and update installations. It is by far the most widely used tool for updating Windows systems, primarily because it's fully integrated into the operating system itself. Windows update can be centrally controlled and administered via Group Policy and also through editing the local registry.⁷ A drawback of Windows Update is that it can only update the local system and is set up by default to download all updates from Microsoft's remote site—thereby potentially causing network bandwidth utilization issues.

Microsoft also provides a freeware utility called Software Update Services (SUS)⁸ for centrally managing service packs, critical updates, and hotfixes. This utility provides a local repository of updates from which Windows clients download their updates. It also allows administrators to test the updates before deploying them and comes with a user friendly Web-based interface. This tool can significantly ease the burden of patching Windows systems and

⁷ <http://support.microsoft.com/?kbid=328010>

⁸ Download this free software at <http://www.microsoft.com/windows2000/windowsupdate/sus/default.asp>.

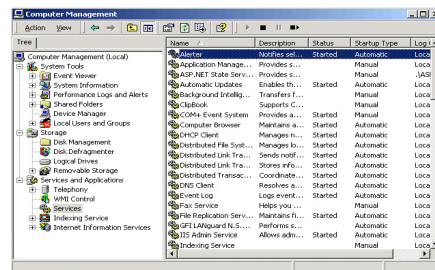
is recommended. For more information, see *Deploying Microsoft Software Update Services* [Microsoft 03a].

Visit <http://www.susserver.com/> for useful information on SUS including troubleshooting, FAQs, and forums. SUSserver.com describes themselves as “a collection of technical information and resources to assist in the implementation and troubleshooting of Microsoft Software Update Services.”

Hardening Windows 2000 Systems - 4

Hardening Windows Services

- Should disable or set many services to start manually rather than automatically (depending on role of server)
- Examples: Alerter, Messenger, Netmeeting Remote Desktop, Fax Service, DHCP client (on servers) etc.



*Demo: Harden
Services on W2K
File Server*

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Module 1: Host System Hardening and Availability Monitoring – slide 11

1.4.5 Hardening Windows Services

Windows 2000 Server has over 40 services that start automatically and another 20 ready to start whenever the system deems it necessary. These services consume system resources (the default load eats up over 100 MB of memory) and also open the door to potential security incidents. Services can be set to start automatically upon boot or they can be set to start manually whenever the system or application (with privileges) needs it, or they can be disabled. There is no exact formula to describe exactly which service should be installed on every kind of system. All environments have unique differences. Therefore, it's best to understand what each service actually does and then decide whether individual services can be disabled or at least set to start manually. Here are two resources that describe Windows 2000 services fairly comprehensively:

- <http://www.microsoft.com/windows2000/techinfo/howitworks/management/w2kservices.asp>
- <http://www.blackviper.com/WIN2K/Files/2000Services.zip>

However, there are some services that are widely considered to be unnecessary for Windows 2000 servers in most environments. Consider disabling the following after a thorough analysis of each service's potential impact on your environment: Alerter, Distributed Link Tracking, Distributed Transaction Coordinator, Fax Service, Indexing Service, Internet Connection Sharing, Messenger, DHCP Client, NetMeeting Remote Desktop Sharing, QoS RSVP, Remote Access Auto Connection Manager, Remote Access Connection Manager, Remote Registry Service, Routing and Remote Access, Smart Card, Smart Card Helper, Telnet, and Uninterruptible Power Supply.

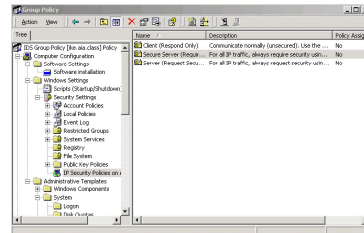
You can manually tweak individual services one at a time by using the services snap-in for Microsoft Management Console (MMC). From the Start menu, select Run and type

“services.msc.” However, the services can also be configured all at once by utilizing security templates and Group Policy.

Hardening Windows 2000 Systems - 5

Use Group Policy and Active Directory to Administer Enterprise-Wide Security

- Over 400 available settings via Group Policy MMC
- Can apply to organizational units (OUs), domains via Active Directory Users and Computers—very granular implementation of security policies



Demo: Applying GPOs

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Module 1: Host System Hardening and Availability Monitoring – slide 12

1.4.6 Group Policy and Active Directory

Group Policy is an Active Directory-based mechanism for controlling user and computer desktop environments in Windows 2000 domains. Settings for such items as security, software installation, and scripts can be specified through Group Policy. Group Policy is applied to groups of users and computers based on their location in Active Directory.

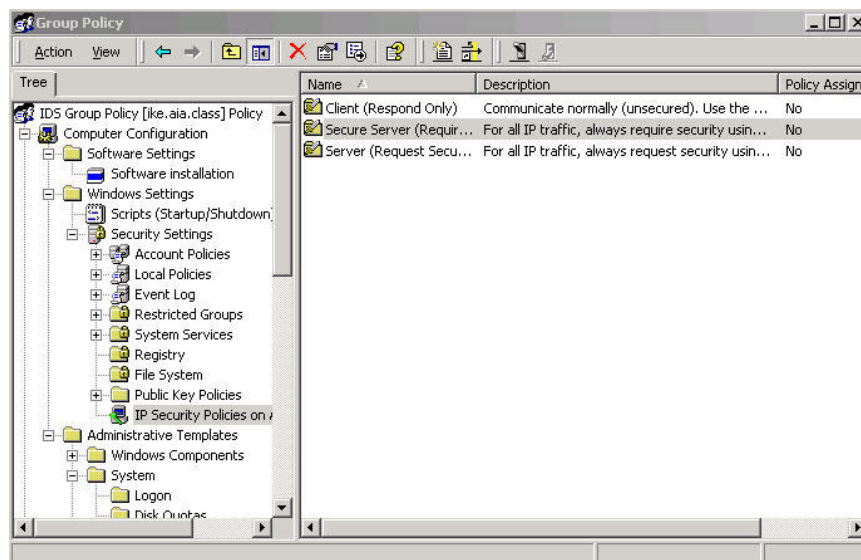


Figure 1: Group Policy Microsoft Management Console (MMC)

Group Policy settings are stored in Group Policy objects (GPOs) on domain controllers. GPOs are linked to containers—sites, domains, and organizational units (OUs)—within the Active Directory structure. Because Group Policy is so closely integrated with Active

Directory, it is important to have a basic understanding of Active Directory structure and security implications prior to implementing Group Policy. Group Policy is an essential tool for securing Windows 2000. It can be used to apply and maintain a consistent security policy across a network from a central location [NSA 03c]. As mentioned in the slide on page 19, a great amount of granularity is provided by Group Policy. Hundreds of environment variables and policies can all be centrally configured and deployed with the convenience of a very easy to use interface.

GPOs can be created and/or edited in one of two ways:

1. In the MMC, load the Group Policy snap-in.
2. In the Active Directory Users and Computers or Active Directory Sites and Services tools, specify a new Group Policy for a container.

The latter is the preferred method as it clearly shows and maintains the GPO scope.

Linking a GPO to a site, domain, or OU causes the settings in the GPO to affect computer or user objects in that container. GPO linking to Active Directory container objects is flexible. A single GPO can be linked to multiple sites, domains, and OUs. Also, multiple GPOs can be linked to a single site, domain or OU. When a GPO is created, it is automatically linked to the container in which it is created. None of the 400-plus settings are initially defined. GPOs linked to domains and OUs are created using Active Directory Computers and Users. GPOs linked to sites are created using Active Directory Sites and Services. When deciding to unlink a GPO from a container, it is recommended that only the link, and not the entire GPO, be deleted. This allows the GPO to be relinked later in case there is a problem. It is possible to create an unlinked GPO for a given domain with the Group Policy MMC snap-in and link it to an Active Directory container object at some future time. To reduce unnecessary complexity and avoid misconfiguration, it is recommended that GPOs not be linked to sites as a general rule.

A GPO linked to a domain applies to all users and computers in the domain. By inheritance, it is also applied to all users and computers in child OUs. Within a domain tree, Group Policy is not inherited between domains. For example, a GPO in a parent domain will not apply to its child domains. A GPO linked to an OU is applied to all users and computers in the OU. By inheritance, the GPO is also applied to all child OUs under the parent OU. By default, only domain administrators and enterprise administrators have the authority to link GPOs to domains and OUs, and only enterprise administrators have the authority to link GPOs to sites. Members of the Group Policy creator owners group can create and modify GPOs for the domain, but cannot link them.

GPOs are cumulative; the last GPO applied overrides previously applied GPOs. When multiple GPOs exist within a container's hierarchy, this is the order in which they are processed and applied:

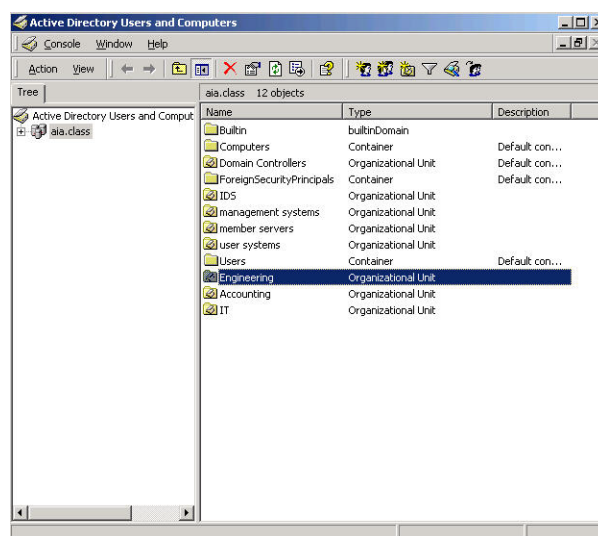
- Local GPO
- Site GPO
- Domain GPO
- Organizational unit GPO
- Child OU GPO

Group Policies are cumulative, as long as they do not conflict. In other words, if a given container object links to multiple GPOs, the non-conflicting settings from all of the GPOs will affect that container. There is one exception to the accumulation rule: when processing IP Security or User Rights settings, the last GPO processed overwrites any previous GPOs. When GPOs conflict, the last setting to be processed generally applies. The two clear-cut cases for this rule are parent/child settings and settings from multiple GPOs linked to the same container. When settings from different GPOs in the Active Directory parent/child hierarchy conflict, the GPO settings for the child container apply. When settings from multiple GPOs linked to the same container conflict, the settings for the GPO highest in the list apply. Administrators can rearrange this list to raise or lower the priority of any GPO in the list [NSA 03c].

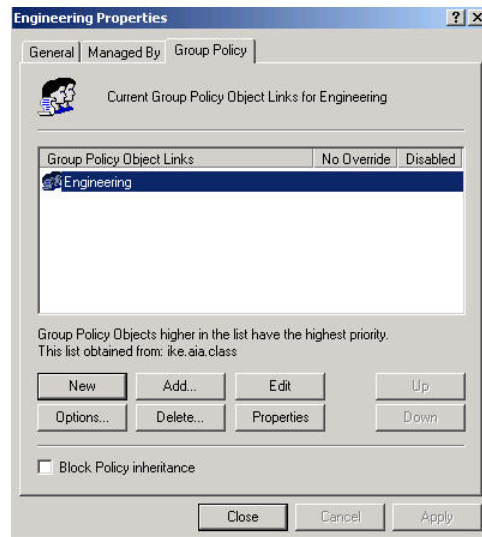
Creating, Configuring, and Linking a New GPO

To make this easier to grasp, let's create a new GPO, configure it, and link it to an Active Directory container—in this case, the Engineering Organizational Unit.

1. First, we'll open the Active Directory Users and Computers MMC snap-in on our Windows 2000 domain controller.
2. Then we right click on the Engineering OU and select properties.

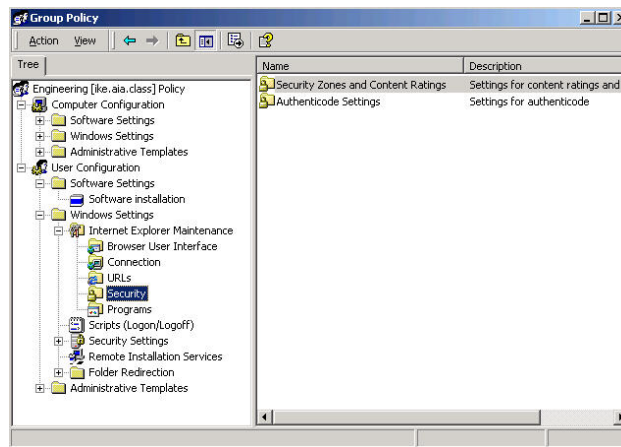


3. We'll click the Group Policy tab and then click the New button and name the GPO Engineering.



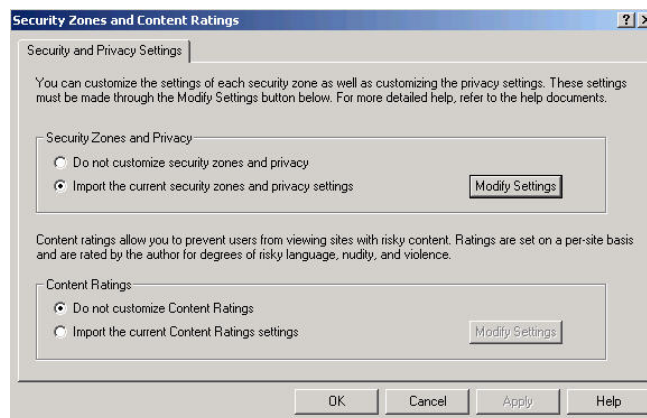
4. Now we'll click the Edit button to configure the settings of this specific GPO.

5. In this case, we're only going to make one configuration; we need to edit the security settings of the Engineering users' Internet Explorer browser so a specific URL is added as a Trusted Site (for easier collaboration with other developers).

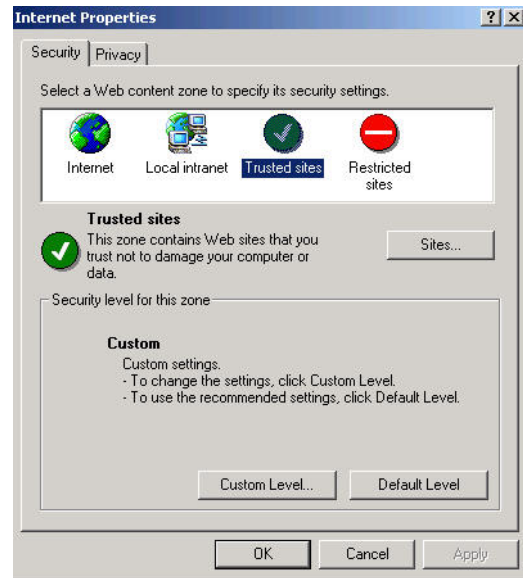


6. In the MMC, we select User Configuration > Windows Settings > Security > and double click Security Zones and Content Ratings.

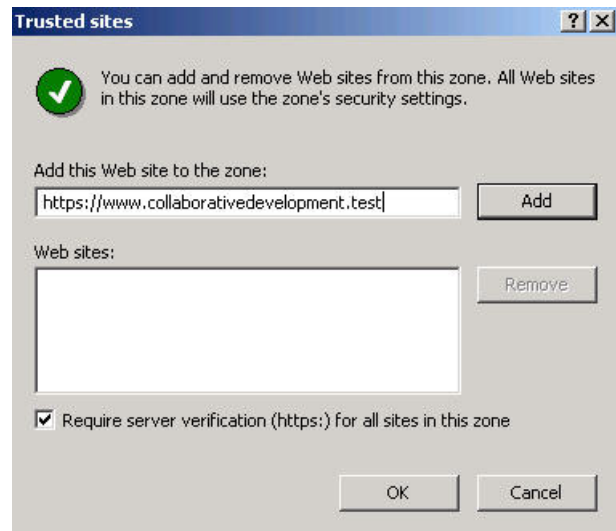
7. We click Import the current security zones and privacy settings and then click the Modify Settings button.



8. We select Trusted Sites and then click the Sites button.



9. Now we'll add the collaborative development URL to the list by clicking Add and then OK.



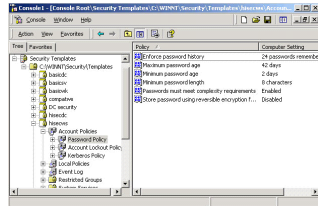
10. Now we click OK a few times and the GPO is created, configured, and linked to the Engineering OU.

This new IE setting will be applied when users assigned to the Engineering OU log in to the domain or through periodic policy refreshes. Group Policy is powerful and really quite easy to use.

Hardening Windows 2000 Systems - 6

Use Windows 2000's Security Configuration Toolset to edit and apply Security Templates—standardizing system security

- Can be used to make registry settings, configure applications
- Enforce file system security settings, account/password policies
- Can be implemented centrally within a Windows 2000 domain by using Group Policy Objects (GPOs) or applied to local host systems



Demo: Apply Security Templates to systems via GPOs

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Module 1: Host System Hardening and Availability Monitoring – slide 13

1.4.7 Security Configuration Toolset and Security Templates

Windows 2000 includes support for the Security Configuration Tool Set. The tool set allows system administrators to consolidate many security-related system settings into a single configuration file (called a template or inf file because of the file extension “.inf”). It is possible to layer security configuration files to adjust for different software applications and security settings. These security settings may then be applied to any number of Windows 2000 machines either as part of a GPO or through local computer configuration.

The Security Configuration Tool Set can be used to analyze and configure the following areas:

- account policies – includes Password Policy, Account Lockout Policy, and Kerberos Policy
- local policies – includes Audit Policy, User Rights Assignment, and Security Options
- event log – includes settings for the event logs
- restricted groups – includes membership settings for sensitive groups
- system services – includes configurations for system services such as network transport
- registry – includes registry key Discretionary Access Control List (DACL) settings (i.e., registry key permissions)
- file system – includes NTFS file and folder DACLs (i.e., file and folder permissions)

In actuality, the Security Configuration Tool Set consists of two MMC snap-ins: Security Configuration and Analysis and Security Templates.⁹

⁹ <https://www.microsoft.com/WINDOWS2000/techinfo/howitworks/security/sctoolset.asp>

Security Configuration and Analysis

The Security Configuration and Analysis MMC allows administrators to

- create and/or edit security configuration files
- perform a security analysis
- graphically review the analysis results
- apply a security configuration to a local system

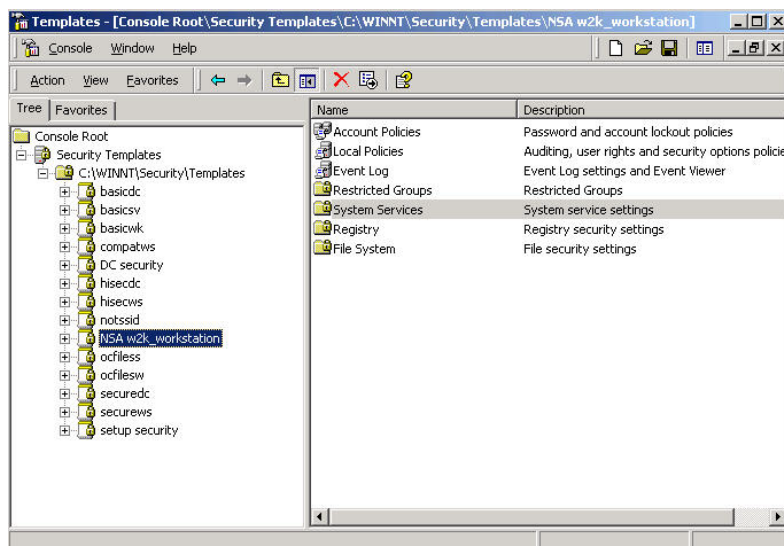
The GUI provides different colors, fonts, and icons to highlight the differences between the baseline information and the actual system settings. When an analysis or configuration is performed, all security areas within a security template are included in the analysis.

Security Templates

Security templates are files that contain a set of security configurations. Using templates is an easy way to standardize security across a platform or domain. Templates can be applied to Windows 2000 computers either by being imported into a GPO or by being directly applied to the local computer policy. Templates cannot be applied to a system or group of systems using the Security Templates MMC, which only allows administrators to create, view, and edit security templates (.inf files). Templates can be imported into GPOs or they can be applied to local systems using the Security Configuration and Analysis MMC [NSA 03d].

To help you understand this better, let's view and then edit a security template provided by the NSA, import it into a GPO, and then apply the template to our User Systems OU.

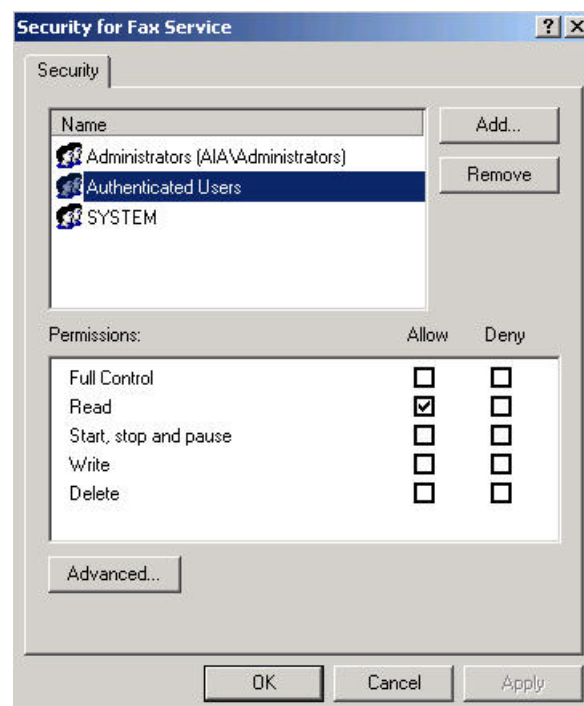
1. First, let's open the Security Templates MMC and edit the NSA's Windows 2000 Professional template file (NSA w2k_workstation). This template is one of several that come with the *NSA Guide to Securing Microsoft Windows 2000 Group Policy: Security Configuration Tool Set* [NSA 03d].



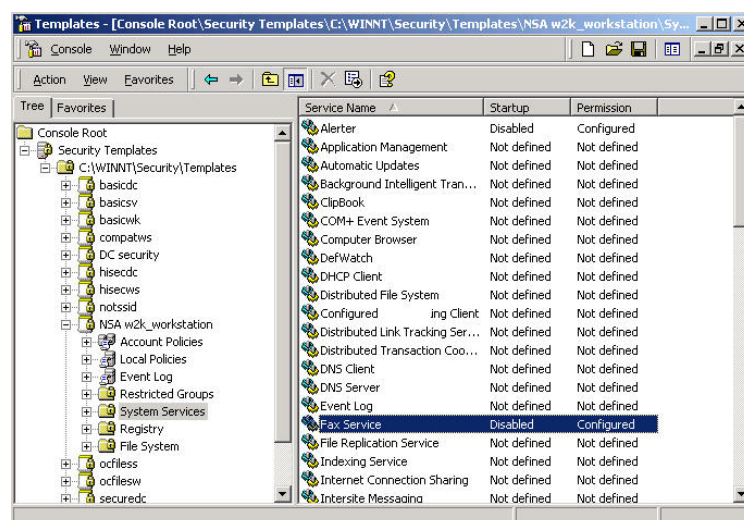
For this example, we'll disable the fax service on all user systems.



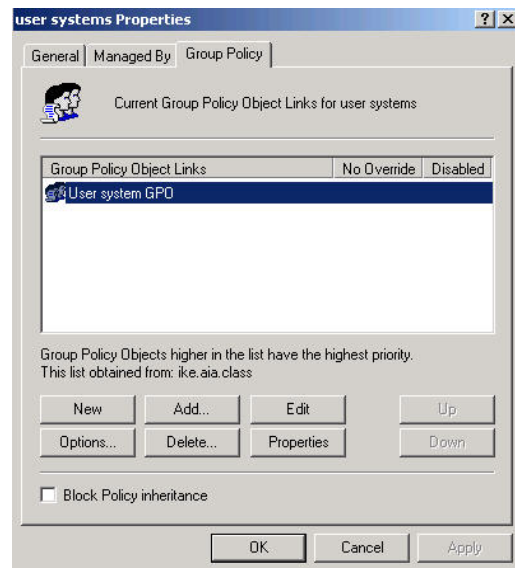
2. When configuring system services with security templates, you must configure the Access Control List (ACL) for each service. When a service is explicitly disabled, its ACL should also be secured by changing the default ACL from Everyone Full Control to grant Administrators and SYSTEM Full Control and Authenticated Users Read Access.
3. Click OK on both of the dialogue boxes and then check your template's setting for the fax service; it should be disabled.



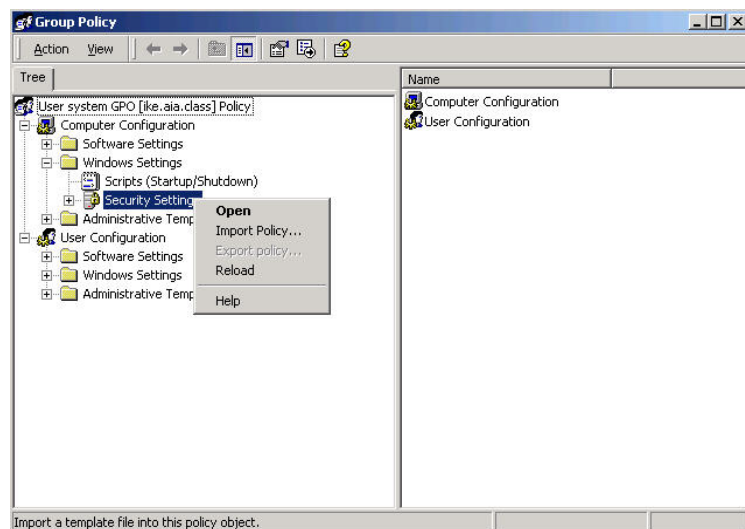
4. Now we have to save our changes to the template. Right click on the NSA w2k_workstation template and then click Save.



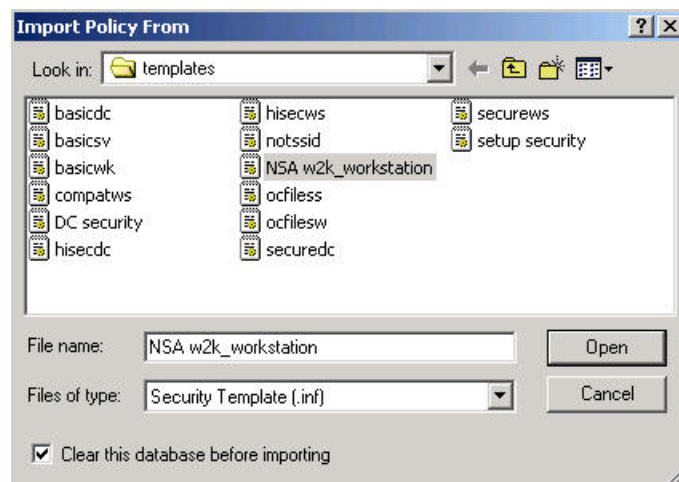
5. The next step is to import this template into a Group Policy Object that is Linked to our User Systems OU. Open the Active Directory Users and Computers MMC on your Windows 2000 domain controller and then right click on the User Systems OU.
6. Click Properties and then click on the Group Policy Tab. Select the User System GPO (in this case the GPO was already created).
7. Now we'll click the Edit button and then browse within the Group Policy MMC to Computer Configuration > Windows Settings > Security Settings.



8. Now right click on the Security Settings container and click Import Policy.



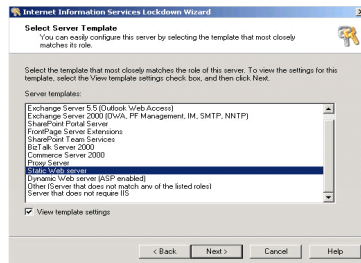
9. Select our newly edited NSA w2k_workstation template and then click Open.
10. Click OK a couple of times and we've just applied all of the good security settings configured by the NSA (as well as one of our own) to all of our user systems.



Hardening Windows 2000 Systems - 7

Harden Internet Information Services (IIS)

- NTFS Permissions on Web Sites
- IIS Lockdown Wizard and URLScan.exe
- IIS Authentication techniques



Demo: IISLockd.exe

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Module 1: Host System Hardening and Availability Monitoring – slide 14

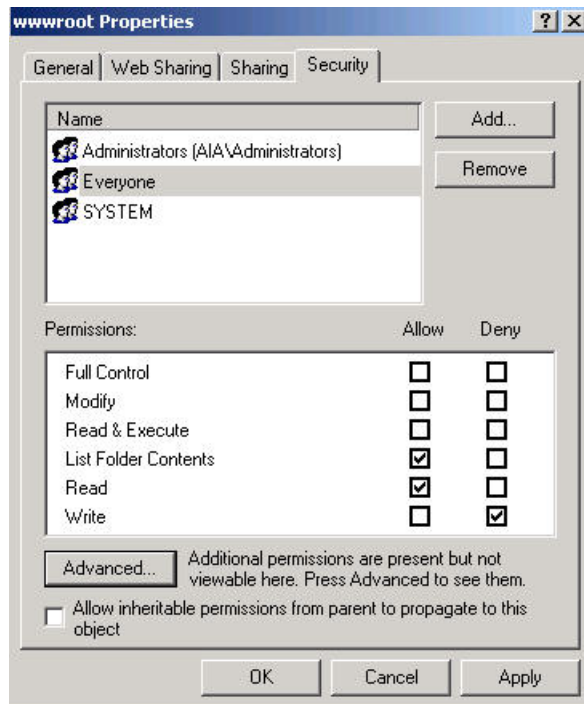
1.4.8 Harden Internet Information Services (IIS)

It's no secret that IIS has had plenty of bugs in its code—so much so that Gartner, Inc. recommended that it be entirely replaced in favor of a more secure solution [Bryce 01]. Gartner has been criticized for this, because IIS is so widely implemented and because IIS can, in fact, be rather secure—if the administrator is vigilant and well informed. Microsoft has provided truckloads of whitepapers, checklists, and tools for securing IIS. However, the key is to begin with Windows 2000 Server, because the underlying operating system must be hardened in conjunction with the specific requirements of the service (in this case IIS).

Check the NTFS file and folder permissions for the location of the Web site files. Ensure that only the minimum essential privileges are granted, especially in the case of IIS systems accessible from the Internet.

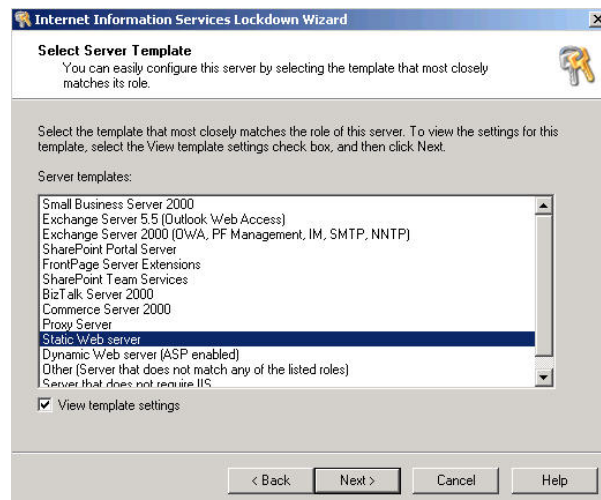
Additionally, consider applying the Hisecweb.inf security template¹⁰ to your IIS server. It is configured by Microsoft to position an IIS server (along with the IISlockd.exe tool) in a very secure state.

The IIS Lockdown Wizard¹¹ is a great utility for hardening some of the weak default settings and other security issues surrounding IIS.



When executed, IISlockd.exe is very straightforward. It starts by checking to see if IIS is installed on the system and whether or not the Lockdown Wizard has been previously run. Then it presents the following series of dialog boxes to help you set up the appropriate configuration for your environment.

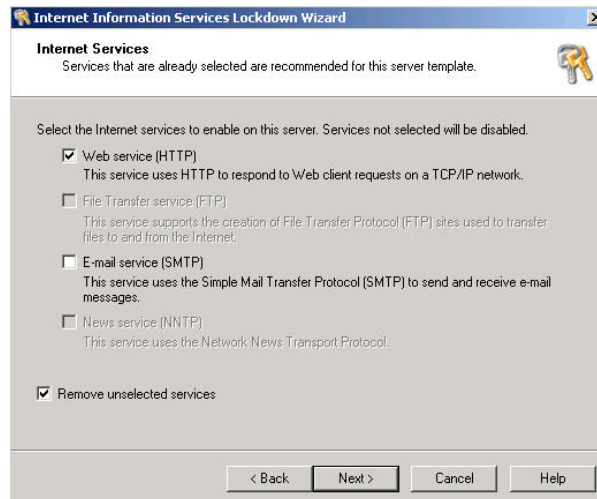
1. Identify the server's role.



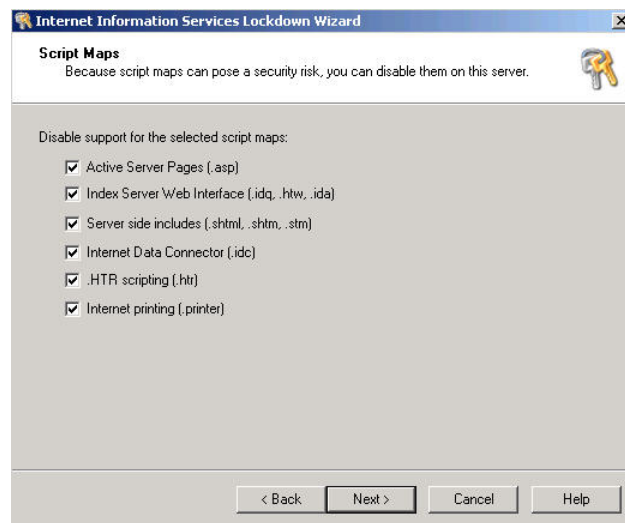
¹⁰ <http://support.microsoft.com/support/misc/kblookup.asp?id=Q316347>

¹¹ This free software may be downloaded from <http://www.microsoft.com/downloads/details.aspx?displaylang=en&FamilyID=DDE9EFC0-BB30-47EB-9A61-FD755D23CDEC>.

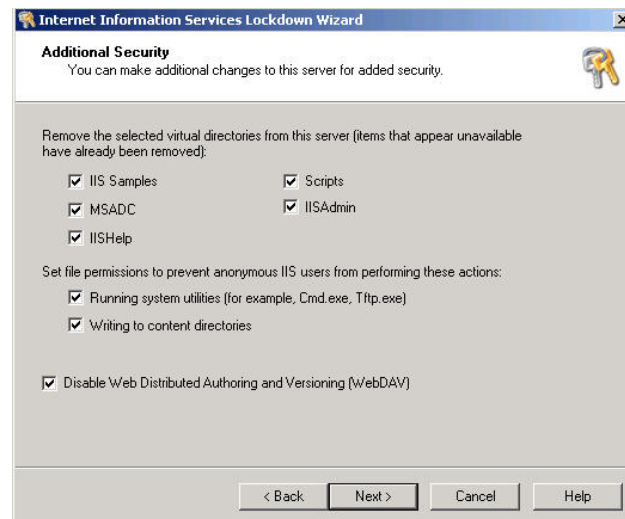
2. Select the Internet service(s).



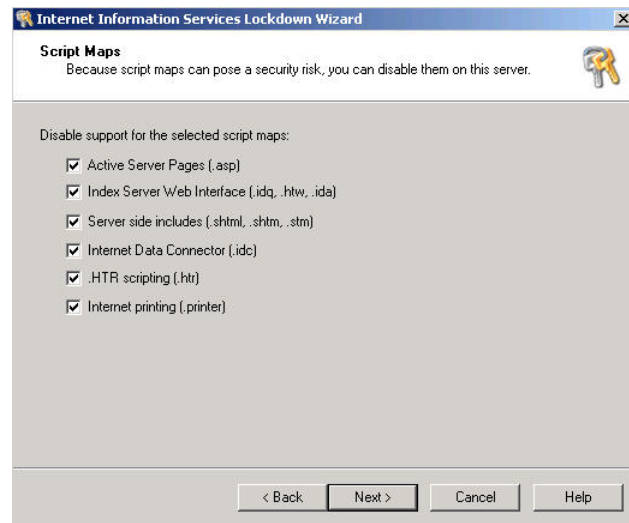
3. Disable Script maps.



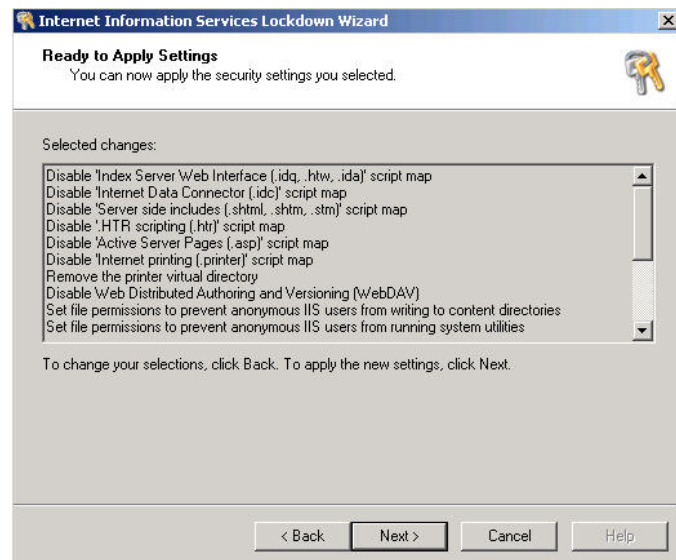
4. Disable weak default features.

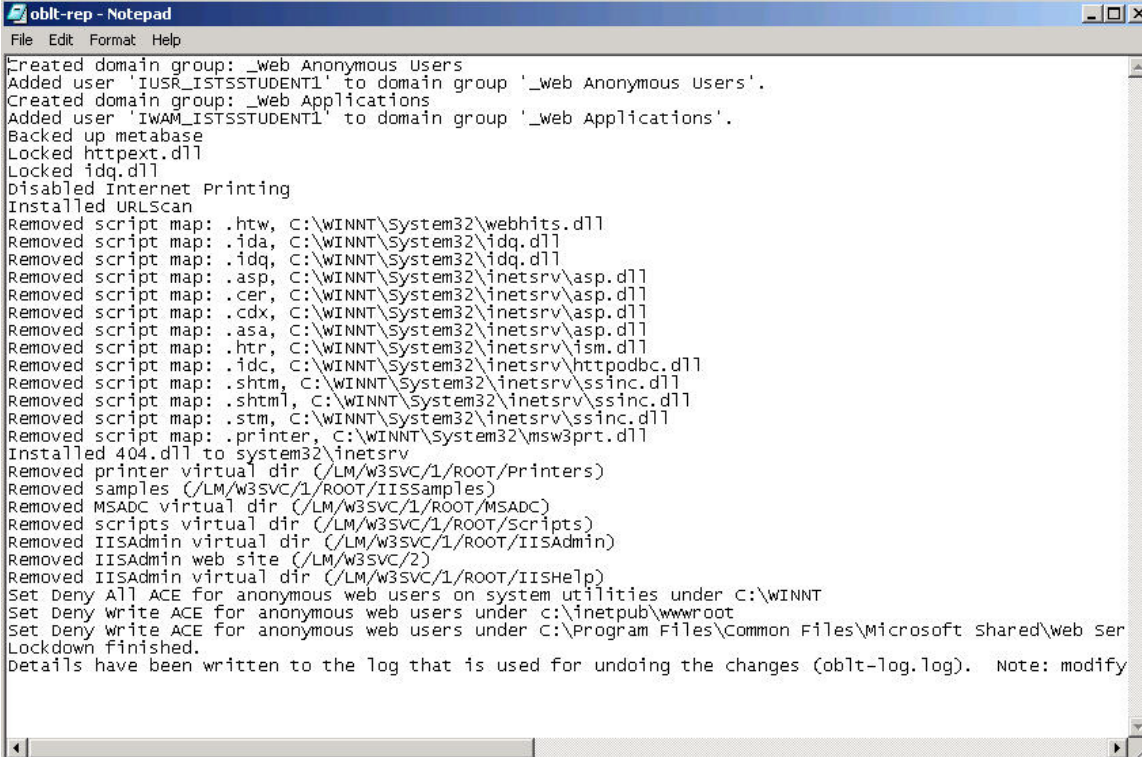


5. Install URLScan.exe.



6. Apply the configuration.





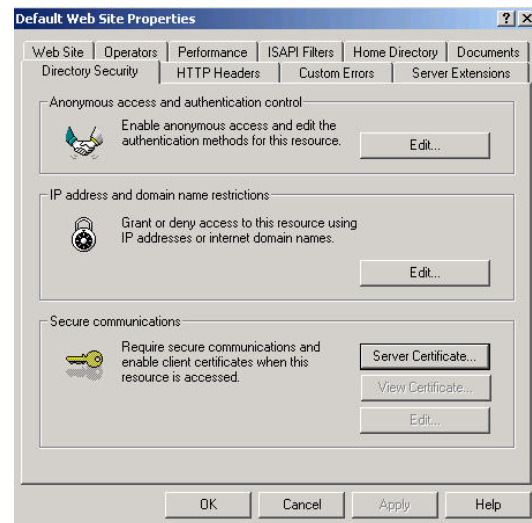
```
oblt-rep - Notepad
File Edit Format Help

Created domain group: _web Anonymous Users
Added user 'IUSR_ISTSSTUDENT1' to domain group '_web Anonymous Users'.
Created domain group: _web Applications
Added user 'IWAM_ISTSSTUDENT1' to domain group '_web Applications'.
Backed up metabase
Locked httpext.dll
Locked idq.dll
Disabled Internet Printing
Installed URLScan
Removed script map: .htw, C:\WINNT\System32\webhits.dll
Removed script map: .ida, C:\WINNT\System32\idq.dll
Removed script map: .idq, C:\WINNT\System32\idq.dll
Removed script map: .asp, C:\WINNT\System32\inetrv\asp.dll
Removed script map: .cer, C:\WINNT\System32\inetrv\asp.dll
Removed script map: .cdx, C:\WINNT\System32\inetrv\asp.dll
Removed script map: .asa, C:\WINNT\System32\inetrv\asp.dll
Removed script map: .htr, C:\WINNT\System32\inetrv\ism.dll
Removed script map: .idc, C:\WINNT\System32\inetrv\httpodbc.dll
Removed script map: .shmt, C:\WINNT\System32\inetrv\ssinc.dll
Removed script map: .shmtl, C:\WINNT\System32\inetrv\ssinc.dll
Removed script map: .stm, C:\WINNT\System32\inetrv\ssinc.dll
Removed script map: .printer, C:\WINNT\System32\msw3prt.dll
Installed 404.dll to system32\inetrv
Removed printer virtual dir (/LM/W3SVC/1/ROOT/Printers)
Removed samples (/LM/W3SVC/1/ROOT/IISamples)
Removed MSADC virtual dir (/LM/W3SVC/1/ROOT/MSADC)
Removed scripts virtual dir (/LM/W3SVC/1/ROOT/Scripts)
Removed IISAdmin virtual dir (/LM/W3SVC/1/ROOT/IISAdmin)
Removed IISAdmin web site (/LM/W3SVC/2)
Removed IISAdmin virtual dir (/LM/W3SVC/1/ROOT/IISHelp)
Set Deny All ACE for anonymous web users on system utilities under C:\WINNT
Set Deny write ACE for anonymous web users under c:\inetpub\wwwroot
Set Deny write ACE for anonymous web users under C:\Program Files\Common Files\Microsoft Shared\Web Ser
Lockdown finished.
Details have been written to the log that is used for undoing the changes (oblt-log.log). Note: modify
```

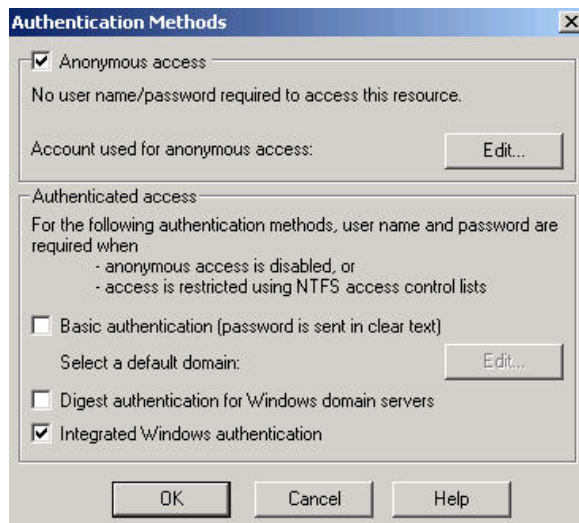
Figure 2: IIS Lockdown Wizard Summary Report

An IIS Lockdown Wizard summary report is shown in Figure 2. The IIS Meta-base is backed up by the wizard so that running it again allows an administrator to revert back to the original IIS server's configuration. For more information about how to harden IIS, see the *Secure Internet Information Services 5 Checklist* [Microsoft 03b] and the *Guide to the Secure Configuration and Administration of Microsoft Internet Information Services 5.0* [NSA 03a].

Within IIS, administrators have the capability to control how users and computers authenticate to the service.

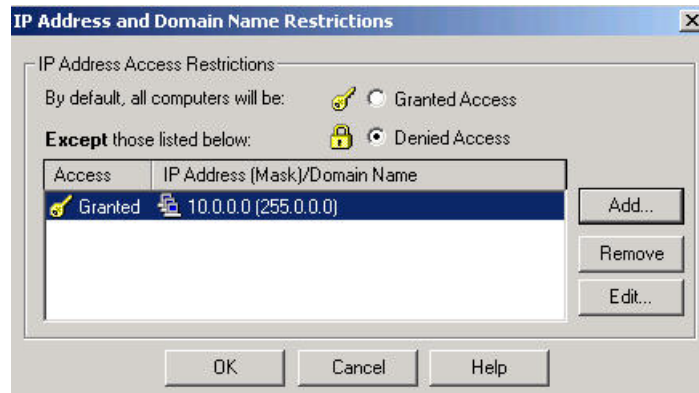


For a public Web server, you will likely enable the default anonymous user authentication method. This means that every time someone on the Internet connects to the service, they are authenticating anonymously with IIS but are actually using a built-in Windows 2000 user account.



Unlike a public Web server, an administrator can require tighter authentication and access controls for an internal Intranet server, where he or she knows who should have access to the service. In the above authentication screenshot you'll see that the administrator would very likely disable anonymous access and utilize stronger authentication from users. As long as users have accounts in the domain, selecting the Integrated Windows authentication or Digest authentication can be transparent from the users' perspective.

The administrator could harden the service further by only allowing connection requests from Internal IP addresses. In this case, only source addresses from the RFC 1918¹² private address space 10.0.0.0 network will be allowed to make a connection. (Although this contributes to the defense in depth goal, it might be done more effectively by a host-based firewall.)



IIS also has the capability to use industrial strength SSL encryption via PKI certificates. IIS can import certificates from trusted CA's (like Verisign) or from an internal certificate server. In the case of the later, it can be configured to authenticate user digital certificates, thereby increasing the reliability of the authentication considerably.

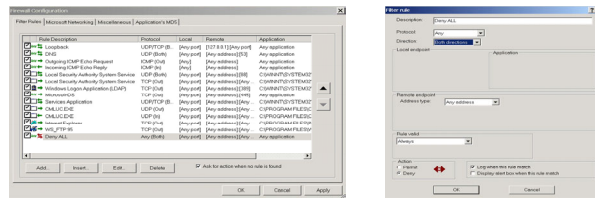
¹² <http://www.isi.edu/in-notes/rfc1918.txt>

Hardening Windows 2000 Systems - 8

Use a host-based firewall to control network access

Many products available, but we're using Tiny Personal Firewall 2.015 (freeware)

- Lightweight, nice user interface, granular configuration of rules, MD5's applications
- Create rules for accepted traffic then create one Deny All rule and log for matches against this rule



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Module 1: Host System Hardening and Availability Monitoring – slide 15

1.4.9 Host-Based Firewalls

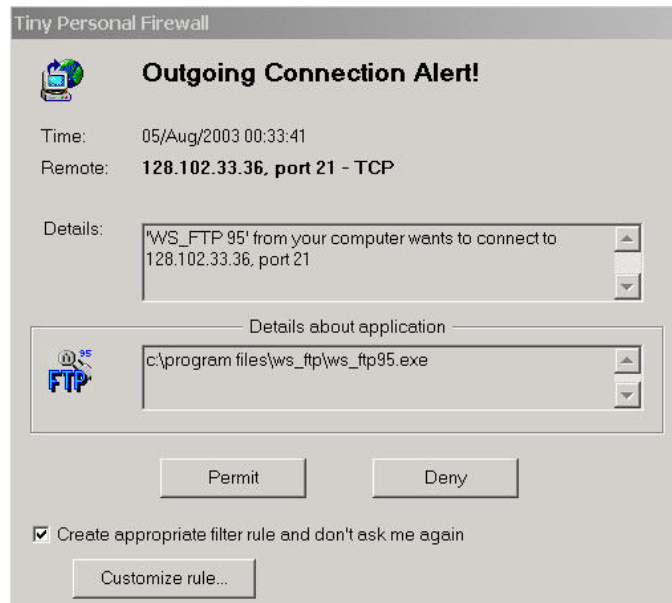
Host-based firewalls are one of the best (and cheapest) ways to significantly harden your host systems. Tiny Personal Firewall (TPF) Version 2.015¹³ has been around for a couple of years and has been scrutinized carefully for security issues. We still find it to be the best free Windows personal firewall out there—mainly because of the granularity it provides regarding rules and features like syslog capability, hashing of registered applications, and its intuitive interface. In fact, we like it better than any of the commercial firewalls we've tried.

Setting up Tiny Personal Firewall

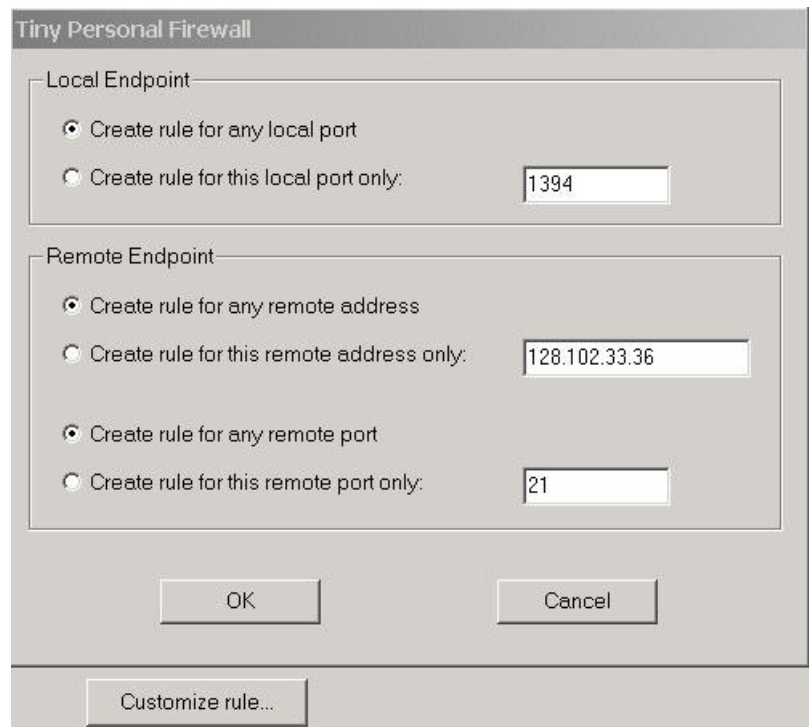
Installing TPF 2.015 is easy and upon the required reboot it will start prompting you to build your rules via pop-up windows. It is very lightweight and doesn't affect performance noticeably even on busy Windows servers.

¹³ This free software may be downloaded at http://download.com.com/3302-2092_4-6313778.html?pn=1&fb=2.

A good strategy with this tool is to keep the default “Ask me First” setting so you can choose to allow traffic on a case by case basis when prompted. You can also click a check box and permanently create a rule in your firewall table so you won’t be prompted in the future.



You have the ability to customize this rule by service ports and IP addresses.



If public services are offered on the protected host, logging should be enabled on the rule that allows the specific traffic into the server. In this example we are allowing TCP traffic destined for our Web server (port 80) application from any Internet host.

The 'Filter rule' dialog box is shown with the following settings:

- Description: Inbound Web traffic only
- Protocol: TCP
- Direction: Incoming
- Local endpoint:
 - Port type: Single port
 - Port number: 80
 - Application: Only selected below (c:\winnt\system32\inetssrv\inetinfo.ex)
- Remote endpoint:
 - Address type: Any address
 - Port type: Any port
- Rule valid: Always
- Action:
 - Permit (selected)
 - Deny
- Log when this rule match (checked)
- Display alert box when this rule match (unchecked)

Finally, an explicit “deny all” rule should be created and all matches against this rule should be logged.

The 'Filter rule' dialog box is shown with the following settings:

- Description: Deny ALL
- Protocol: Any
- Direction: Both directions
- Local endpoint: (empty)
- Application: (empty)
- Remote endpoint:
 - Address type: Any address
- Rule valid: Always
- Action:
 - Permit
 - Deny (selected)
- Log when this rule match (checked)
- Display alert box when this rule match (unchecked)

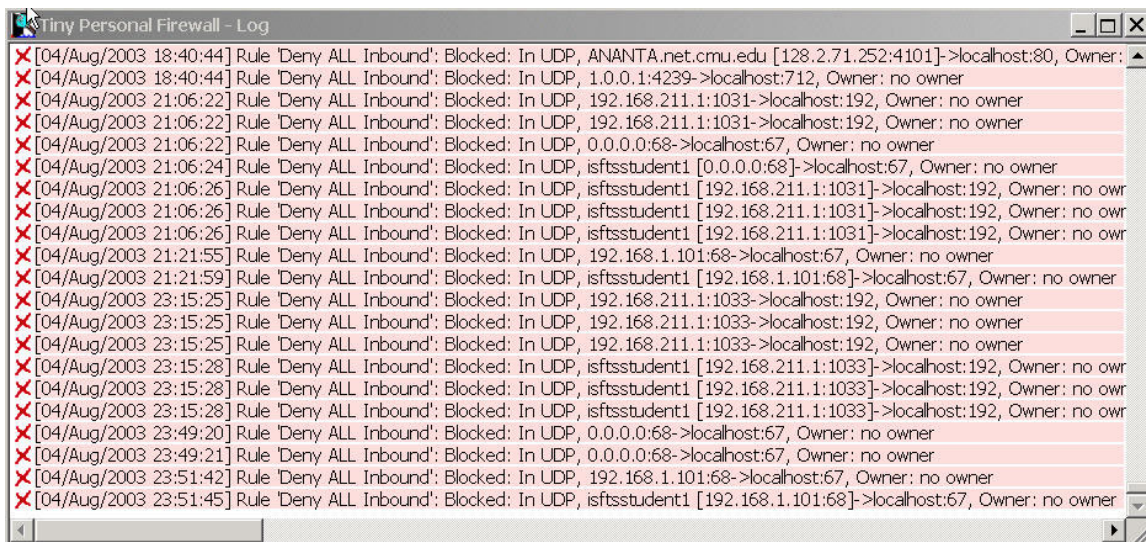


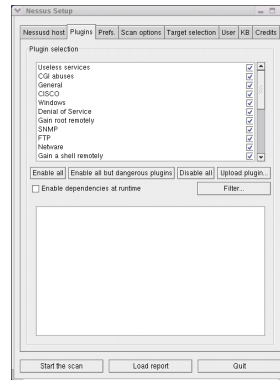
Figure 3: Tiny Personal Firewall Log

Logging matches against this rule allows you to inspect TPF's real-time scrolling log display for patterns of potentially malicious traffic. You can then create new rules that specifically deny this bad traffic to gain access to your public Web server. The built-in convenience of being able to have TPF send all of its logs to a centralized syslog server is a very nice feature, and highly recommended from a security standpoint.

Hardening Red Hat Linux Systems

Determine the initial security posture of system

- Nessus Vulnerability Scanner
- Run nessus-update-plugins script to get the latest vulnerability tests
- Enable only the Linux/Unix and specific service plugins to optimize accuracy of scan



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Module 1: Host System Hardening and Availability Monitoring – slide 16

1.5 Hardening Red Hat Linux Systems

1.5.1 Vulnerability Scanners Explained

A vulnerability scanner is fundamentally different from a port scanner. A port scanner (for example, `nmap`¹⁴) can only provide information about what ports are open and listening. Port scanners cannot even reliably determine what service is running on a particular port. For example, a Web server can be configured to run on port 22 which is normally reserved for SSH. A port scanner will only report that port 22 was found to be open, leading the casual scanner to believe that the SSH service is available on the target system.

Vulnerability scanners like Nessus,¹⁵ on the other hand, take information provided from a port scan and perform various checks to determine what service is running. Therefore, using our previous example, a vulnerability scanner can tell you not only that a Web server is running on port 22 but it will also reveal that the server is Apache 1.3.26 and contains four separate vulnerabilities. This information will be invaluable in hardening your host system.

Nessus Architecture

Nessus is actually comprised of two major components; a server (`nessusd`) which is responsible for performing the scan, and a client (`nessus`) that can parameterize scans and view reports.

¹⁴ <http://www.insecure.org/nmap/>

¹⁵ <http://www.nessus.org>

- **Nessusd:** The server component of Nessus that listens for client connections on TCP port 1241. All client sessions are authenticated using an SSL-like method. While the Nessus client has been ported to many different operating systems, this portion must be installed on a Linux/UNIX system.
- **Nessus:** The Nessus client is the component that scanners use to configure the parameters of Nessus scans. Once the scan has finished, results will also be viewed through the client interface.

Installing and Running Nessus

Nessus installation is an extremely simple process. With the release of Nessus 2.0, the installation process has been automated through the use of the Nessus-installer shell script.

To install Nessus:

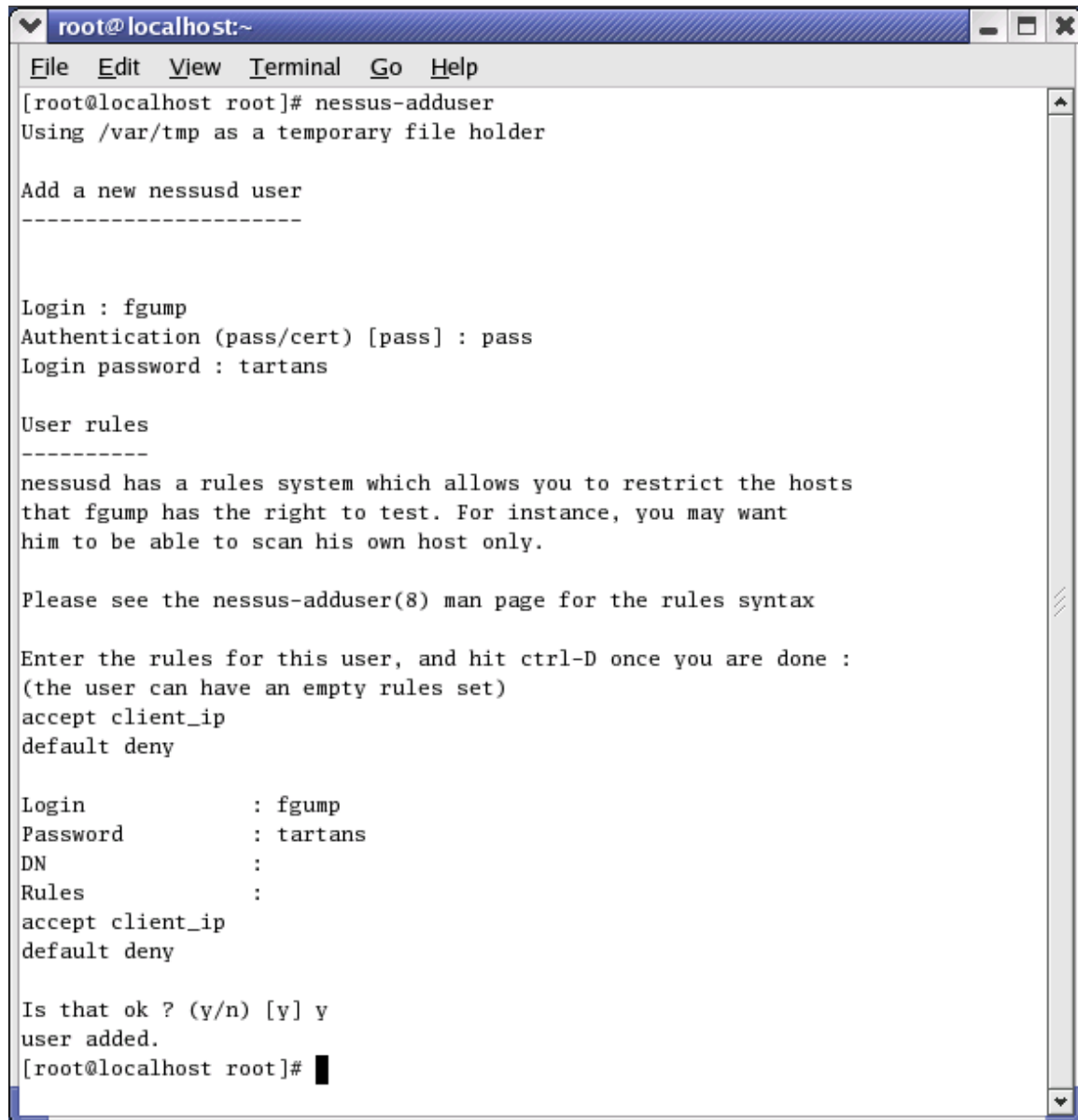
1. Download `nessus-installer.sh` from any of the available mirror sites.
2. Open a shell as root, and enter the following command:

```
% sh nessus-installer.sh
```

This script will handle downloading Nessus packages, compiling (if necessary), and placing files in the proper directories.

Configuring Nessus:

First, create a user account.



```
root@localhost:~  
File Edit View Terminal Go Help  
[root@localhost root]# nessus-adduser  
Using /var/tmp as a temporary file holder  
  
Add a new nessusd user  
-----  
  
Login : fgump  
Authentication (pass/cert) [pass] : pass  
Login password : tartans  
  
User rules  
-----  
nessusd has a rules system which allows you to restrict the hosts  
that fgump has the right to test. For instance, you may want  
him to be able to scan his own host only.  
  
Please see the nessus-adduser(8) man page for the rules syntax  
  
Enter the rules for this user, and hit ctrl-D once you are done :  
(the user can have an empty rules set)  
accept client_ip  
default deny  
  
Login          : fgump  
Password       : tartans  
DN             :  
Rules          :  
accept client_ip  
default deny  
  
Is that ok ? (y/n) [y] y  
user added.  
[root@localhost root]#
```

Figure 4: Adding a User in Nessus

1. At the shell prompt, enter the following command:

```
% nessus-adduser
```

2. Enter a user name.

3. Enter “pass” as the Authentication method. This will tell Nessus to use a password (as opposed to a certificate).
4. Enter a password.
5. Leave the rules section blank. If you wanted to limit a user’s scanning ability, you could enter appropriate rules in this section.
6. Update the Nessus plug-ins to get the latest vulnerability tests.

```
% nessus-update-plugins
```

7. Start the nessusd server with the following command:

```
% nessusd -D
```

Next, create an SSL certificate.

1. At the shell prompt, enter the following command:

```
% nessus-mkcert
```

2. Enter the information that it asks for. This certificate will be presented to all Nessus clients that connect to this server.
3. Press enter to accept the certificate.

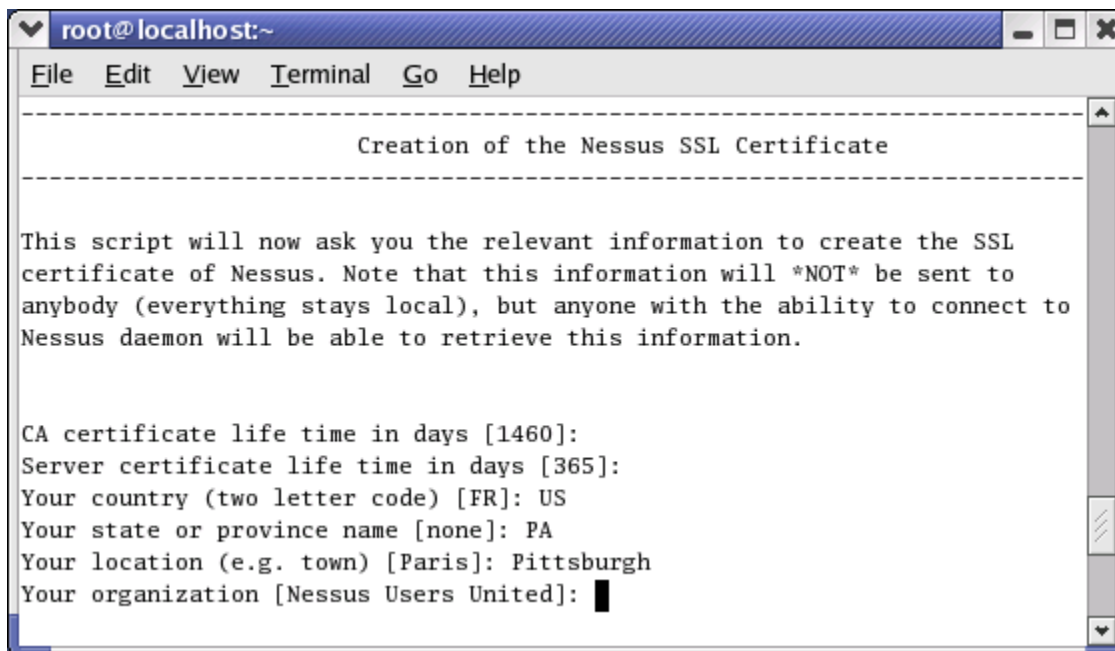


Figure 5: Adding an SSL Certificate

Next, configure Nessus Client.

1. At the shell prompt, enter the following command:

```
% nessus
```

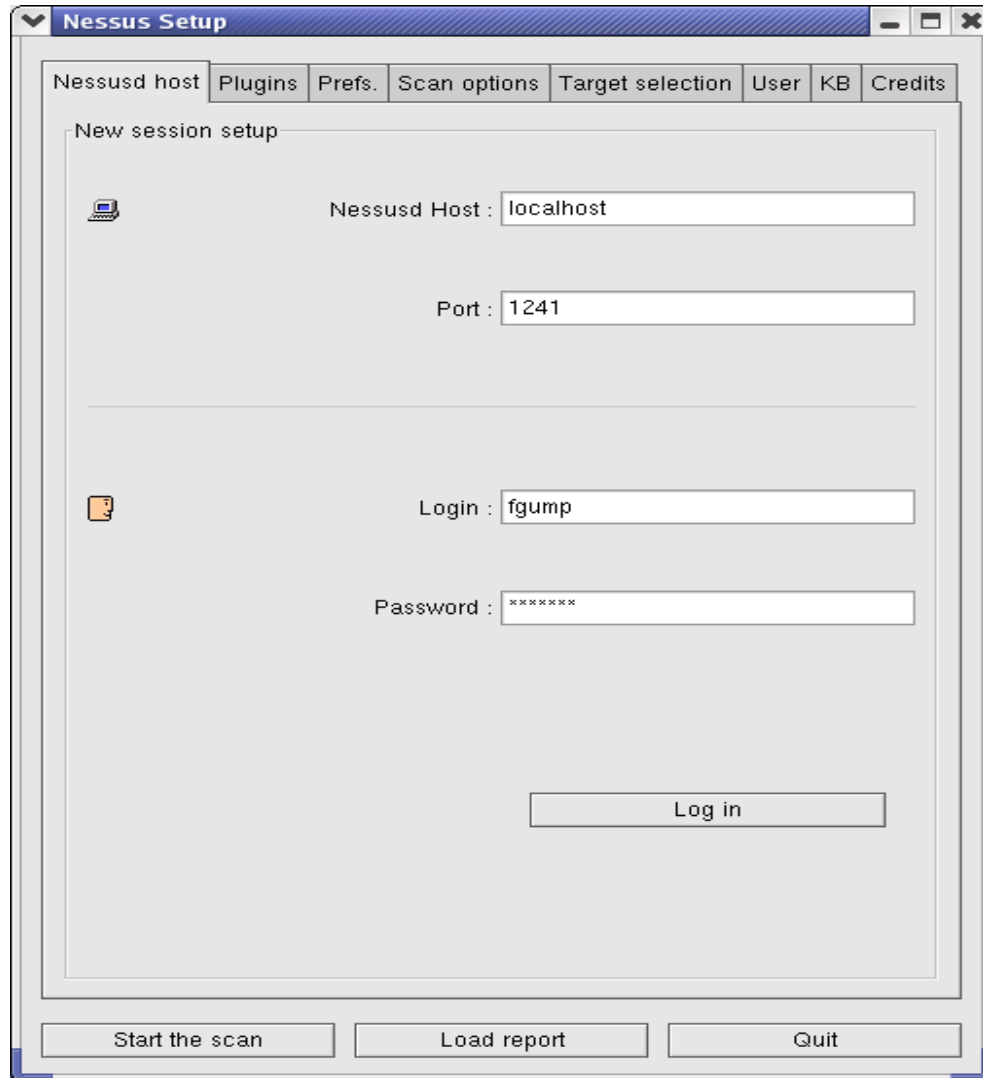


Figure 6: Nessus Intro Screen

2. Before starting a scan, all users must log into the Nessus client.
3. Configure the following scan parameters:

Plug-ins

From this tab, users can select which vulnerability tests will be run on the target host. Since we will be scanning a Linux machine as our target, we should disable all Plugins that are not Linux specific. Minimally, we should remove the Windows, Windows User Management, CISCO, Firewalls, and NetWare plug-ins.

Also, it is probably a good idea to disable the Denial of Service plug-in because we would rather not cause our target host to crash.

Prefs

Allows you to supply extra information to some of the security checks. For instance, you can provide Nessus with specific directories to look for during its FTP and HTTP attacks. Also, you can configure NIDS evasion techniques.

Scan Options

Provides the ability to change certain scan options. You can choose the port scanner to use, how many hosts should be scanned simultaneously and the number of plug-ins to run at the same time.

Target Selection

Specifies the host to be scanned. You can enter a new host, a new network, or you can restore a previously saved session.

User

Allows the user to enter rules that further restrict the scanning ability. For example, if you are scanning a network and there are a small number of hosts you would prefer to ignore, you can enter those hosts in this tab as opposed to dissecting the network into blocks that exclude those hosts.

KB

Using the knowledge base allows for users to perform differential scans. Using the KB tab allows the user to test only unseen hosts (increases speed), or to only report when the security posture of a machine has changed from a previous scan.

4. Click on Start the Scan to begin.

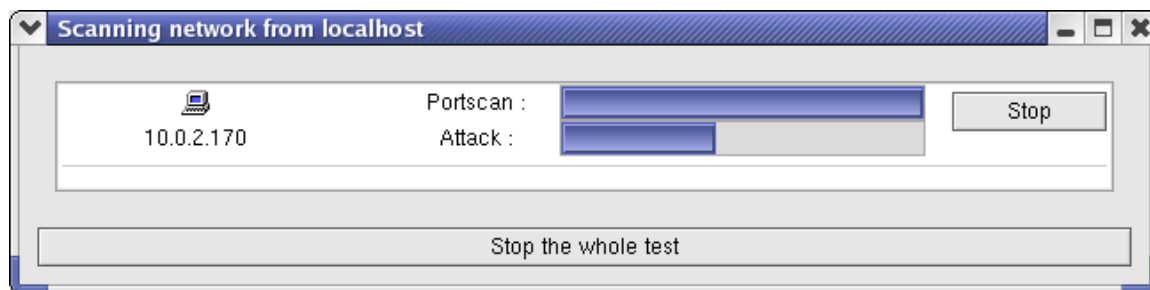


Figure 7: Nessus Scan Progress Indicator

5. Review the results of the scan.

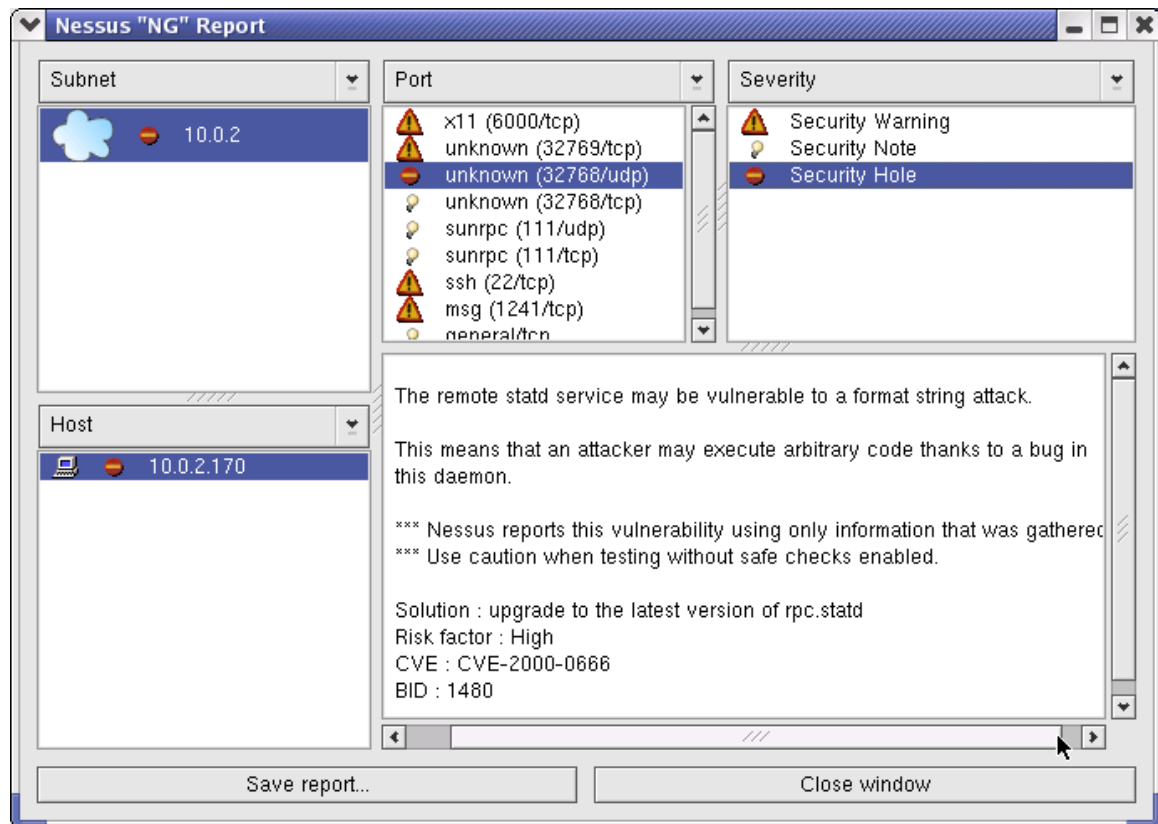
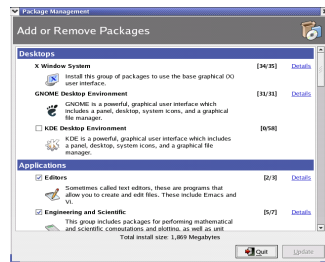


Figure 8: Nessus Scan Results

Hardening Red Hat Linux Systems - 2

Remove unnecessary OS features and applications

- Use RH Package Manager (RPM) to remove unnecessary packages
- Available in command line and graphical formats



Demo: Minimize with RPM

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Module 1: Host System Hardening and Availability Monitoring – slide 17

1.5.2 Minimizing with Red Hat Package Manager

The Red Hat Package Manager is an open software packaging system that greatly simplifies the process of maintaining a system. As the name suggests, RPM originated on the Red Hat distribution of Linux, but it is present and functional on other versions of Linux/UNIX.

One of the most common tasks a system administrator performs is to remove components that correspond to unnecessary operating system features and applications. Many of these features are installed by default and will never be noticed until a security vulnerability is discovered. By removing these extraneous features immediately, we can reduce our future exposure to security risks.

In this example, we will be introducing two of the most powerful features of the RPM system; namely uninstalling packages and querying the rpm database. By default, Red Hat Linux 8.0 installs the ISDN¹⁶ daemon. Currently, there are no known vulnerabilities in the ISDN daemon, but we won't wait for any to be discovered. So let's get rid of it!

In order to remove an rpm, we must first discover the rpm's full name. Use the rpm command with the -qa switch to query all packages:

```
% rpm -qa | grep isdn
isdn4k-utils-3.1-58
xisdnload-1.38-58
```

It appears we need to remove both of these rpms.

¹⁶ http://searchwebservices.techtarget.com/sDefinition/0,,sid26_gci212399,00.html

```
% rpm -e isdn4k-utils-3.1-58
error: Failed dependencies
    isdn4k-utils is needed by (installed) xisdnload-1.38-58
```

It appears that another package depends on the isdn4k-utils package. We have two options at this point. One option would be to ignore this dependency using the `--nodeps` switch. However, that is probably not a good idea because the dependent package cannot be trusted to function properly.

Our other option is to remove the dependent package. Fortunately, in this case, we were going to remove it anyway.

```
% rpm -e xisdnload-1.38-58
% rpm -e isdn4k-utils-3.1-58
```

Now, let's make sure that the ISDN daemon packages have been removed.

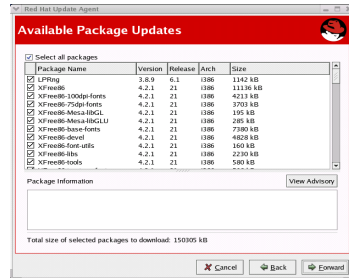
```
% rpm -qa | grep isdn
%
```

We have successfully removed the ISDN packages.

Hardening Red Hat Linux Systems - 3

Solutions for patch management

- up2date tool via Red Hat Network
- Update individual packages from sources (rpms or tarballs)



Demo: up2date

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Module 1: Host System Hardening and Availability Monitoring – slide 18

1.5.3 Patch Management for Red Hat Linux Systems with Up2date

Keeping your operating system and applications current with the latest patches is possibly the easiest way to protect yourself from security vulnerabilities. Even though Microsoft dominates the news concerning patches and security holes, Linux is not without its deficiencies in certain areas. In order to ensure that your system is running at the most current patch level, RedHat has included a tool called “up2date” which functions exactly like Windows Update. Up2date will contact the Red Hat Network and retrieve the latest updates for your operating system.

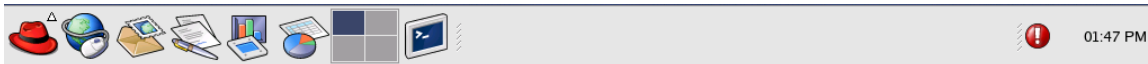


Figure 9: Linux Taskbar with up2date Notification

When you first boot into Linux after a fresh install, the task bar at the bottom of the screen will resemble the one shown in Figure 9 above. The interesting part of the taskbar is the small red circle with the white exclamation point. This icon indicates that your system may need to download critical updates. Here’s how you should proceed:

1. Double click the up2date notification icon. You will be presented with a dialog box similar to that in Figure 10. The two tabs in this dialog box provide a great deal of information about the current state of your system:
 - Available Updates – This tab indicates which updates have yet to be installed on this machine. A fresh Linux install can require a great many updates (as many as 200), whereas current systems will only need the latest patches.

- Ignored Packages – This tab allows you to select any packages that should be ignored during the update process. This can be very helpful in a number of situations. For example, if you have customized the configuration of certain packages (as in a production environment) then you would want to test all changes before updating any package.

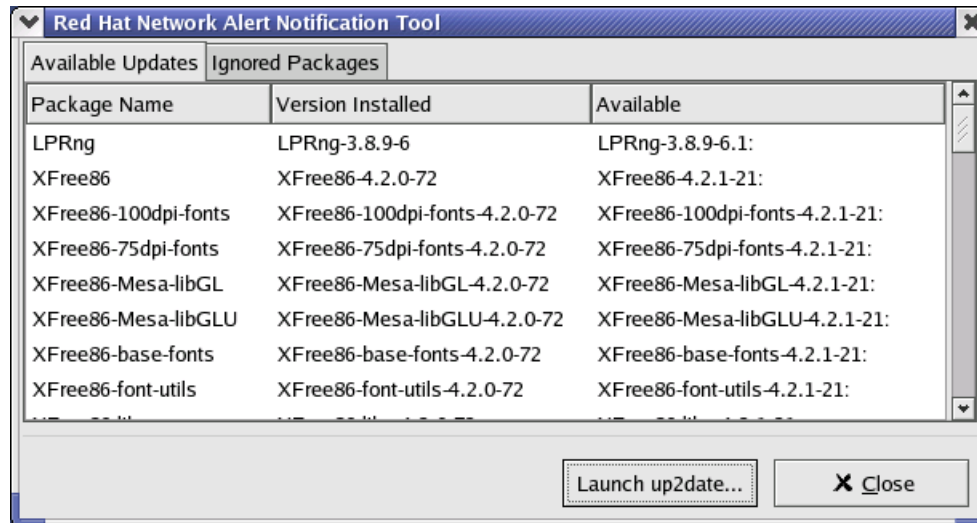


Figure 10: Red Hat Network Update Tool (up2date)

2. Click the “Launch up2date” button shown in Figure 10 above. You will be presented with the Red Hat Update Agent.
3. On the Welcome screen, click the “Forward” button to proceed to the channels screen.
4. The channels screen presents the Red Hat channels available to your system. Choose your favorite channel and proceed.
5. The “Packages Flagged to be Skipped” screen displays any packages that should be ignored in the update process. The one package that typically appears in this screen is the kernel package. The kernel is responsible for the basic functions of the operating system (memory allocation, input/output, etc), and as such it is the most sensitive piece of Linux. If you wish to update the kernel, then it is recommended that you perform an update for that specific purpose after the other packages are updated. Proceed to the next screen.
6. On the available packages screen, choose the packages that you want installed, and proceed.

Up2date will download/install all of the requested packages.

Hardening Red Hat Linux Systems - 4

Securing Red Hat Linux Services

- Use chkconfig—list to see what services are running
- Remove services from /etc/init.d directory to stop them from loading upon boot-up
- Remove all services not explicitly required to function (i.e. xinetd services, etc.)

```

root@localhost: ~
[root@localhost ~]# ls /etc/init.d/
firstboot  isdn      nagios    ntpd      sendmail  syslog
anacron    functions kdcrotate named     pcnclia   single    tux
apmd       gpe       keytable  netfs     portmap   sasl      webmin
atd        halt      killall   network   random    snmpd     winbind
autofs     httpd     kudzu     nfs       rawdevices snaptrapd xfs
bcn5820    iptables lpd       nfslock   rhnsd     squid     xinetd
crond      irda      mysql     nscd      saslauthd sshd       ypbind
[root@localhost ~]#
  
```

Demo: Removing xinetd

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Module 1: Host System Hardening and Availability Monitoring – slide 19

1.5.4 Securing Red Hat Linux Services

As you watch Linux boot up, you might notice that the operating system starts a great deal of services initially. What you might not realize is that, like Windows, many of these services are unnecessary and can be safely stopped or removed. Great! How do you find out what is running and how do you stop a service? Linux makes this whole process very straightforward.

Run Levels

First, before we can disable a service, we need a little background on run levels. Run levels represent all of the modes in which a Linux system can boot. Though this varies from UNIX to UNIX (Linux, AIX, HP-UX, etc) they are very similar. These are the run levels for Linux (excerpted from /etc/inittab):

- 0: Halt (Stops the OS and sometimes powers down the system)
- 1: Single user (Doesn't start network, no password for root. Needed for debugging)
- 2: Multi-user (Starts the whole OS, but does not mount remote file systems)
- 3: Full multi-user (Starts the whole OS and remote file systems, also called text mode)
- 4: Unused
- 5: X-windows (Boots system directly into X-windows GUI)
- 6: Reboot (reboots machine)

On a Linux machine, all information about services is stored in the `/etc/rc.d` directory (see Figure 11).

```
% ls /etc/rc.d
init.d      rc0.d      rc2.d      rc4.d      rc6.d      rc.sysinit
rc          rc1.d      rc3.d      rc5.d      rc.local
```

Figure 11: Contents of rc.d Directory

There are two interesting points concerning this output. The first item of note is that the `init.d` directory contains the startup scripts for every service that might be started by the system (see Figure 12).

```
% ls /etc/rc.d/init.d
anacron  gpm      killall  nscd      saslauthd  xfs
apmd     halt     kudzu    ntpd      sendmail   xinetd
atd      iptables lpd       pcmciasingle ypbind
autofs   irda     netfs    portmap   snmpd
crond    isdn     network  random    snmpttrapd
firstboot kdcrotate nfs       rawdevices sshd
functions keytable nfslock   rhnsd     syslog
```

Figure 12: Contents of init.d Directory

The second item is that a directory exists for each run level. Run level 0 corresponds to `rc0.d`, run level 1 corresponds to `rc1.d`, and so on. These `rc[0-6].d` directories control which services are loaded in each run level. Since this machine is booted into X-windows, we are in run level 5, and thus all the files in the `/etc/rc.d/rc5.d` directory were executed when this machine booted up. The contents of the `rc5.d` directory are displayed in Figure 13:

```
% ls /etc/rc.d/rc5.d
K05saslauthd  S14nfslock    S55sshd      S60lpd
K20nfs        S05kudzu      S17keytable   S80sendmail
K24irda       S08iptables   S20random     S85gpm
K50snmpd      S09isdn       S24pcmcia     S90crond
K50snmpttrapd S10network    S25netfs      S90xfs
K47nscd       S12syslog     S26apmd       S95anacron
K47ntpd       S13portmap    S28autofs     S95atd
K95firstboot  S56rawdevices S56inetd      S99local
```

Figure 13: Contents of rc5.d Directory

In the output above, each file has an “S” or a “K” before it, followed by a number and then the service name. The files that start with “K” are killed (not started) on this run level whereas those beginning with an “S” are started in order from lowest number to highest number. In this example, S10network will start before S56inetd (network services).

Note: More about the Linux boot process is available in Chapter 3 of *The Official Red Hat Linux Reference Guide* [Red Hat 03].

Now that we know how the system starts its services, we can check to see which ones are running by using the `chkconfig` command. The `chkconfig` command shown in Figure 14 will query all services and return an alphabetized list displaying only the services that are listed as “on.”

% chkconfig --list grep on sort							
anacron	0:off	1:off	2:on	3:on	4:on	5:on	6:off
apmd	0:off	1:off	2:on	3:on	4:on	5:on	6:off
atd	0:off	1:off	2:off	3:on	4:on	5:on	6:off
autofs	0:off	1:off	2:off	3:on	4:on	5:on	6:off
crond	0:off	1:off	2:on	3:on	4:on	5:on	6:off
gpm	0:off	1:off	2:on	3:on	4:on	5:on	6:off
iptables	0:off	1:off	2:on	3:on	4:on	5:on	6:off
isdn	0:off	1:off	2:on	3:on	4:on	5:on	6:off
keytable	0:off	1:on	2:on	3:on	4:on	5:on	6:off
kudzu	0:off	1:off	2:off	3:on	4:on	5:on	6:off
lpd	0:off	1:off	2:on	3:on	4:on	5:on	6:off
netfs	0:off	1:off	2:off	3:on	4:on	5:on	6:off
network	0:off	1:off	2:on	3:on	4:on	5:on	6:off
nfslock	0:off	1:off	2:off	3:on	4:on	5:on	6:off
pcmcia	0:off	1:off	2:on	3:on	4:on	5:on	6:off
portmap	0:off	1:off	2:off	3:on	4:on	5:on	6:off
random	0:off	1:off	2:on	3:on	4:on	5:on	6:off
rawdevices	0:off	1:off	2:off	3:on	4:on	5:on	6:off
rhnsd	0:off	1:off	2:off	3:on	4:on	5:on	6:off
sendmail	0:off	1:off	2:on	3:on	4:on	5:on	6:off
sshd	0:off	1:off	2:on	3:on	4:on	5:on	6:off
syslog	0:off	1:off	2:on	3:on	4:on	5:on	6:off
xfs	0:off	1:off	2:on	3:on	4:on	5:on	6:off
xinetd	0:off	1:off	2:off	3:on	4:on	5:on	6:off

Figure 14: Output from `chkconfig`

The example system has been started in run level 5 (X-windows), so a quick glance at column 5 will show all the services that are currently running. Note also that these are all the files that began with an “S” in the `/etc/rc.d/rc5.d` directory.

Now, since this machine is not a mail server, there is no reason for us to be running `sendmail`.¹⁷ Given `sendmail`’s particularly checkered past (some consider it to be the buggiest daemon ever written); there is reason to be seriously concerned. So let’s remove it!

¹⁷ <http://www.sendmail.org>

Stopping a Service

There are two steps that must be executed to stop a service. First you must terminate the currently running service, and then you must prevent it from starting in the future.

1. Stop the service.

```
% service sendmail stop
```

2. Prevent the service from starting in the future.

Remove the service. The following command will remove any references to the sendmail service from all run levels (use this command only if you are really sure that you won't need to use a particular service):

```
% chkconfig --del sendmail
```

By running `chkconfig --list` again, you can see that the sendmail service is no longer listed.

Alter the run level properties of the service. Instead of removing the service entirely, you can simply turn off the service in specific run levels. The following command will mark sendmail as “off” in run levels 3 and 5. Note: you should never turn a service “on” in run levels 0 or 6 (system shutdown and reboot, respectively).

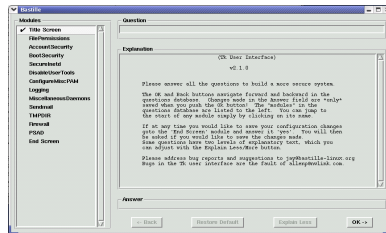
```
% chkconfig --level 35 sendmail off

% chkconfig --list sendmail
sendmail    0:off  1:off  2:on   3:off  4:on   5:off  6:off
```

Hardening Red Hat Linux Systems - 5

Use Bastille tool to automatically harden system

- Edits ACLs, config files, security settings on Unix systems
- Instructional graphical interface with in-depth explanations
- Can quickly revert/undo changes made that may have caused problems—**test** on non-production systems first!



Demo: Bastille

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Module 1: Host System Hardening and Availability Monitoring – slide 20

1.5.5 Bastille-Linux

Bastille-Linux is a user-configurable series of PERL scripts that can be run on an installation of Linux/UNIX to “harden” the operating system. Currently, Bastille supports RedHat, Mandrake, Debian, SuSe, and TurboLinux distributions as well as HP-UX and MacOS X.

The Bastille scripts allow a system operator to easily implement industry “best practices” to dramatically increase the security of the operating system. Bastille was developed according to the recommended security configurations published by CERT, SANS, and other security authorities. In particular, the scripts can disable unnecessary services, secure default configurations, configure logging, and set up a firewall based upon specific system needs.

How Bastille-Linux Works

Bastille-Linux works by systematically working through a comprehensive list of potential security vulnerabilities. At each step, Bastille asks the user to customize the security settings for a particular facet of the operating system.

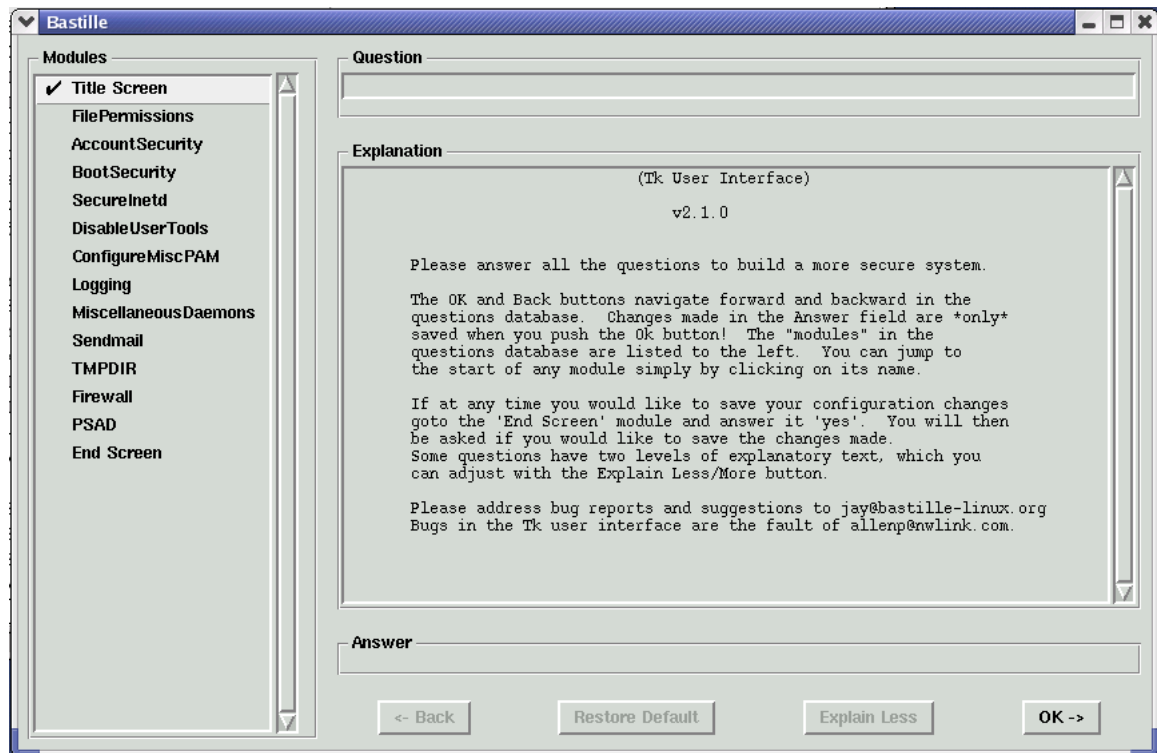


Figure 15: Bastille Intro Screen

The left-hand portion of Bastille's intro screen lists the extensive security settings available through the configuration utility:

- **File Permissions** restricts access to network utilities including `ifconfig` and `runlevel` which are normally reserved for system administration. It will also disable the use of the notoriously vulnerable `r-tools` (`rlogin`, `rsh`, etc.).
- **Account Security** helps enforce account management policies including password aging, access to setting cron jobs (similar to Task Scheduler in Windows), and the root account's ability to log in remotely.
- **Bootup Security** allows an administrator to control how this system can be booted and shut down. The GRUB bootloader can be password protected, and the use of CTRL-ALT-DEL to reboot can be disabled.
- **Securing Inetd** restricts the ways in which users can connect to this system remotely. The cleartext telnet and FTP services can be disabled and administrative banners such as "Authorized Use Only" can be created.
- **Disable User Tools** allows access to the `gcc` compiler to be restricted. Typically, malicious attackers will upload source code to a victim machine after gaining illicit access. Disallowing access to a compiler can delay or possibly stop further damage from occurring.

- **Configuring PAM** sets restrictions on usage of system resources. Console access (which typically includes special system-level access rights) can be restricted to certain users. Configuring PAM also allows you to set limits on the number of processes users can own. Limiting processes is useful because it will prevent a single user from executing a denial of service attack by forking enough processes to starve legitimate programs.
- **Logging** configures the syslog service, allowing an administrator to specify which events should be logged and then port these logs to a centralized syslog server.
- **Misc. Daemons** disables system daemons which are often unneeded given the configuration of the system and the information provided to Bastille thus far.
- **TMPDIR** configures user accounts to avoid using /tmp for storage of temporary files. Security issues arise when the /tmp directory is abused on a multi-user system
- **Firewall** creates an IPtables-based firewall. A very comprehensive list of questions follow which allow the firewall to be customized with respect to features including services to be allowed/rejected, services to audit, default policies, and others.
- **PSAD**, which stands for Port Scan Attack Detector, can be configured to run at varying intervals with customizable parameters such as time between scans, number of suspicious packets seen, use of Snort signatures, etc. (This setting is only available if the firewall is configured as well.)

Depending on the configuration of the host system, several other categories may also appear. These categories include sendmail, DNS, Apache, printing, and FTP.

Once all of the questions have been answered, Bastille performs a validity check on your answers and then customizes its scripts to apply the changes it can do automatically. After performing the actions it can do automatically, the tool produces a “to do” list (/var/log/Bastille/TODO) that describes remaining changes that the user must perform manually. This list includes reboots as changes may require.

Running Bastille-Linux

Bastille-Linux supports two methods of configuration: interactive and non-interactive. First time users must use interactive mode to create a configuration profile.

- **Interactive Use:** The user interface guides the user through a series of questions. Each step contains a description of the security decision being suggested as well as the cost/benefit of the decision
- **Non-Interactive Use:** Useful for duplicating a security configuration across multiple machines that have the same operating system and applications installed.

Much of the power of Bastille-Linux is derived from its interactive setup routine. It is for this reason that we suggest use of this mode.

Bastille itself can be run with the simple steps shown below:

1. Consult the Bastille-Linux Web site¹⁸ to download and install the appropriate modules.
2. Become root and start Bastille using the following command:

```
% bastille
```

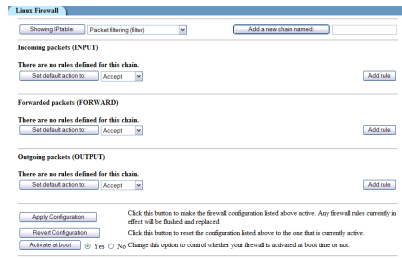
3. Answer the questions Bastille poses.
4. Save your configuration file.
5. Apply the changes.

¹⁸ <http://www.bastille-linux.org/>

Hardening Red Hat Linux Systems - 6

Use IPtables Firewall to configure network access controls

- Easy configuration of rules with Webmin utility
- Set default policy to reject, then configure permit rules for approved traffic—configure logging for rejected packets



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1.5.6 IPtables Firewall

Linux has many built-in capabilities that allow developers and system administrators to customize the behavior of the operating system without requiring expensive third party tools. One such capability that has been available since the 2.4 kernel is IPtables, which is a host-based firewall configuration system.

At its core, the IPtables system behaves as a stateful packet filter. (For more on stateful packet filtering, see section 2.4.1, Stateless and Stateful Packet Filtering, on page 74.) Based on the specific role of the system (e.g., router, workstation), administrators craft rules that govern how the IPtables systems treats the traffic that passes over the network.

How IPtables Works

In order to understand how IPtables works, you must understand how packets traverse the IPtables chains. Figure 16 represents the portion of the IPtables packet filter that is relevant for host based firewalls. In this diagram, the three rectangles (INPUT, FORWARD, and OUTPUT) represent the three chains that will be used to create our firewall.

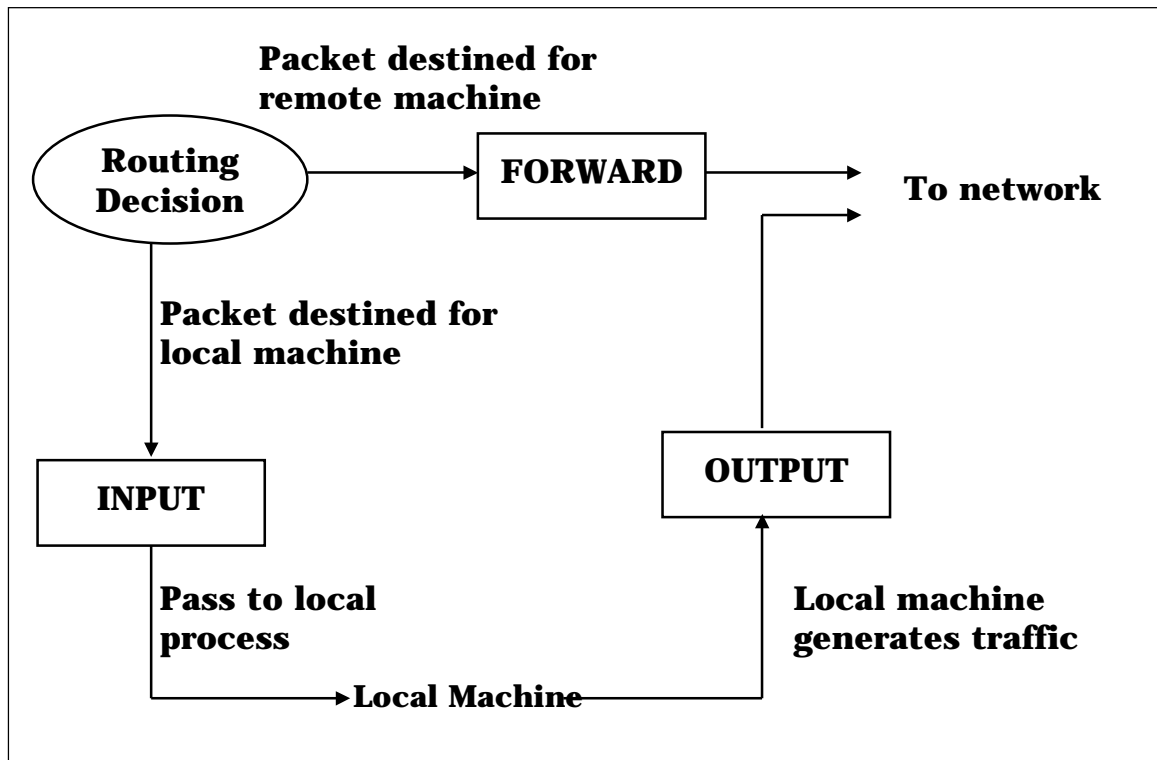


Figure 16: Host-Based IPtables Chains

The following steps are excerpted from *Linux iptables How To* [LinuxGuruz 03]:

1. When a packet arrives, the system will inspect the packet header to discover the destination.
2. If the packet is destined for the local machine, it is passed down to the INPUT chain. If it passes the chain (i.e., there are no rules that indicate the packet should be dropped) then any processes waiting for that packet will receive it.
3. If the packet is destined for a remote machine and either of the following conditions exist, then the packet is dropped.
 - The system has forwarding disabled.
 - The system does not know how to route the packet.If forwarding is enabled, and the packet is destined for another network, then the packet traverses the FORWARD chain. If the packet passes this chain, it will be sent out.
4. Finally, a program running on the local machine can generate network traffic. These packets will traverse the OUTPUT chain. If the packet passes this chain, it will be sent out.

When packets are inspected while traversing the chains, the system will apply user-specified rules in the order they were entered. Therefore, as soon as a packet matches a particular rule, it will “jump” to the rule’s target (e.g., ACCEPT, REJECT, DROP, etc.) and exit the chain. If

a packet does not match any of the rules, it is said to “fall off” the chain and it will be handled by the default policy of the chain. In keeping with best practices, we will have our firewall set up to deny all traffic not explicitly allowed, and so the default policy for our chains will be DROP.

As you might have noticed, we will not make use of the FORWARD chain because our machine is a workstation and will not be performing routing tasks. The chains we are primarily concerned with are the INPUT and OUTPUT chains. These two chains will allow us to explicitly define what traffic is allowed into and out of a particular system.

Configuring IPtables Using Webmin

Using Webmin¹⁹ to configure an iptables firewall is surprisingly easy. On the opening Webmin screen, select the Networking icon at the top of the screen, and then click on the Linux Firewall icon. You should be presented with a screen that looks much like the one shown in Figure 17.

Linux Firewall

Showing IPtable: Packet filtering (filter) Add a new chain named:

Incoming packets (INPUT)

There are no rules defined for this chain.

Set default action to: Accept Add rule

Forwarded packets (FORWARD)

There are no rules defined for this chain.

Set default action to: Accept Add rule

Outgoing packets (OUTPUT)

There are no rules defined for this chain.

Set default action to: Accept Add rule

Apply Configuration Click this button to make the firewall configuration listed above active. Any firewall rules currently in effect will be flushed and replaced

Revert Configuration Click this button to reset the configuration listed above to the one that is currently active.

Activate at boot ☒ Yes ☐ No Change this option to control whether your firewall is activated at boot time or not.

Figure 17: Webmin IPtables Configuration

On this screen you can see the three chains mentioned before, namely INPUT, FORWARD and OUTPUT, as well as their default policies. In this case, all are set to ACCEPT. At this point, we have no rules configured for any of the chains. Initially our host machine generates the nmap run shown in Figure 18.

¹⁹ <http://www.webmin.com>


```

C:\WINNT\System32\cmd.exe

C:\>nmap 10.0.2.170

Starting nmap U. 3.00 ( www.insecure.org/nmap )
Interesting ports on (10.0.2.170):
(The 1596 ports scanned but not shown below are in state: closed)
Port      State      Service
22/tcp    open      ssh
111/tcp   open      sunrpc
1723/tcp  filtered  pptp
6000/tcp  open      X11
10000/tcp open      snet-sensor-mgmt

Nmap run completed -- 1 IP address (1 host up) scanned in 8 seconds

```

Figure 18: The Nmap Run Before Firewalling

Let's say that we want this system to allow only Webmin traffic. We do this by adding the appropriate rules to the INPUT chain, and then setting the default policy to DROP.

Chain and action details

Part of chain Incoming packets (INPUT)
Rule comment Allow Webmin Traffic
Action to take ☐ Do nothing ☒ Accept ☐ Drop ☐ Userspace ☐ Exit chain ☐ Run chain

The action selected above will only be carried out if **all** the conditions below are met.

Condition details

Source address or network <Ignored>
Destination address or network Equals 10.0.2.170
Incoming interface <Ignored> eth0
Outgoing interface <Ignored> eth0
Fragmentation ☒ Ignored ☐ Is fragmented ☐ Is not fragmented
Network protocol Equals TCP
Source TCP or UDP port <Ignored> Port(s)
Destination TCP or UDP port Equals Port(s) 10000
Source and destination port(s) <Ignored>
TCP flags set <Ignored> SYN ACK FIN RST URG PSN out of
TCP option number is set <Ignored>
ICMP packet type <Ignored> echo-reply
Ethernet address <Ignored>
Packet flow rate <Ignored> / second
Packet burst rate <Ignored>
Connection states <Ignored> New connection (NEW)
Existing connection (ESTABLISHED)
Related to existing (RELATED)
Not part of any connection (INVALID)
Type of service <Ignored> Minimize-Delay (0x10)
Additional parameters

Figure 19: Adding IPtables Rule with Webmin

We set the “Action to take” to ACCEPT and then specify the conditions. Here, we will allow the packet if it is destined for 10.0.2.170 (the address of the host system), the TCP protocol is used, and the destination port is 10000.

The last step we must take is to set the default policy for the INPUT chain to DROP. Setting this feature means that any packets that “fall off” the INPUT chain will be dropped by the firewall.

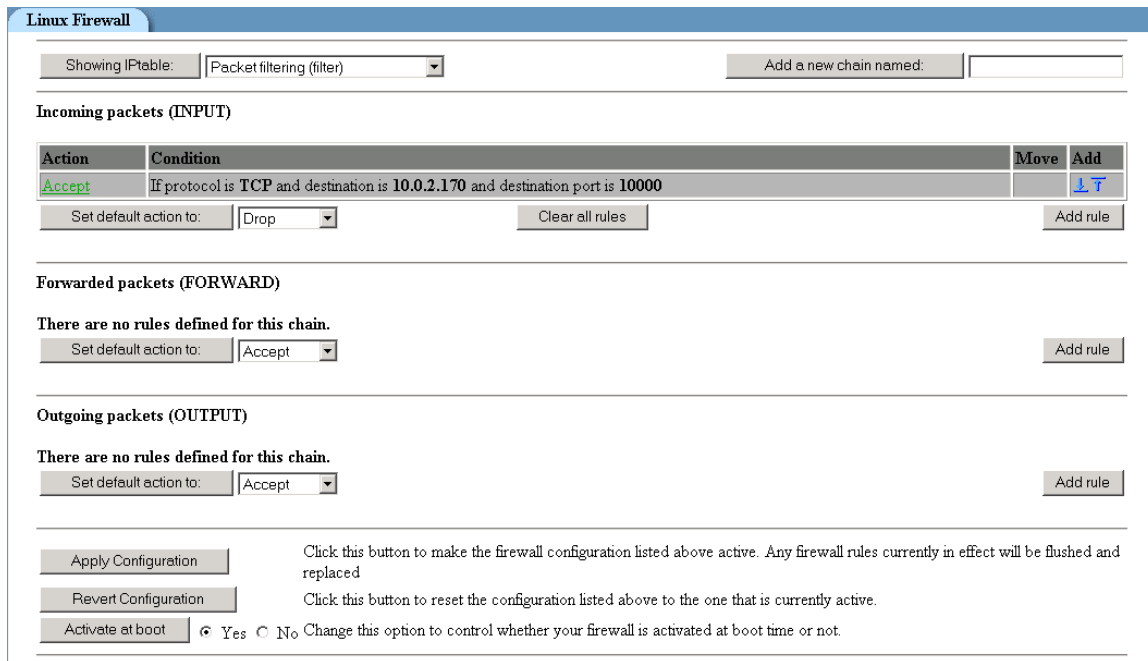


Figure 20: Setting the Default Policy for the INPUT Chain

After changing the default policy, our system generates the nmap run shown in Figure 21.

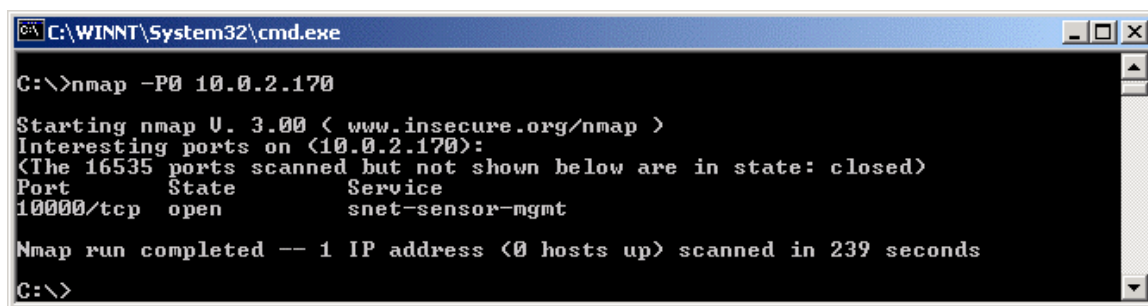


Figure 21: The nmap Run After Firewalling

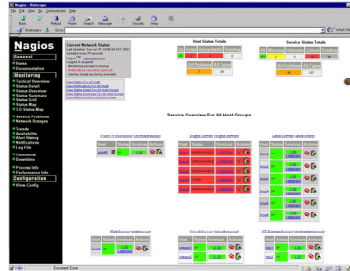
System Availability Monitoring Tools

Nagios

- Open source project
- Very mature and extensible
- Complex installation and configuration

Demarc PureSecure

- Freeware for home use
- Very easy to configure initial monitoring of services



Demo: PureSecure Monitoring Utility

1.6 System Availability Monitoring Tools

The Nagios²⁰ system is an application that monitors hosts, services, and networks. This task is accomplished by intermittently querying each user-configured service and reporting the results back to a central correlation engine. Once the low-level setup has been accomplished, system and network status can be viewed through the use of a Web interface hosted on the Nagios machine itself (see Figure 22).

Demarc's PureSecure²¹ product is actually marketed as an intrusion detection system (a freeware version is available). However, one of its many features is the capability to do remote service availability monitoring. PureSecure is quite easy to configure for initial monitoring of networked services, with all configuration done from within its clean GUI. Pure

²⁰ <http://www.nagios.org/>

²¹ <http://www.demarc.com/>

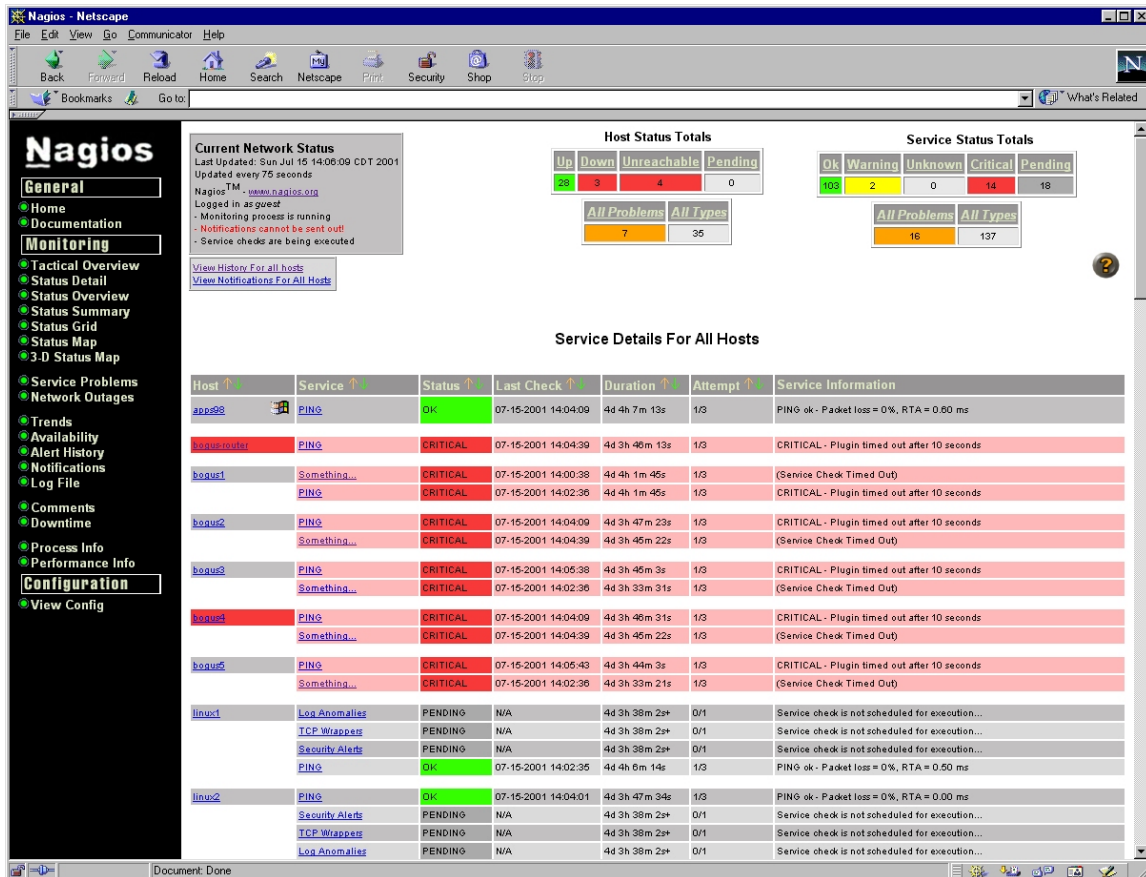


Figure 22: Nagios Web Interface

1.6.1 Nagios

Nagios includes the following features:²²

- monitoring of network services (SMTP, POP3, HTTP, NNTP, PING, etc.)
- monitoring of host resources (processor load, disk and memory usage, running processes, log files, etc.)
- monitoring of environmental factors such as temperature
- simple plug-in design that allows users to easily develop their own host and service checks
- ability to define network host hierarchy, allowing the detection of and distinction between hosts that are down and hosts that are unreachable
- contact notifications when service or host problems occur and get resolved (via email, pager, or other user-defined method)
- optional escalation of host and service notifications to different contact groups
- ability to define event handlers to be run during service or host events for proactive problem resolution

²² <http://www.nagios.org/about.php>

- support for implementing redundant and distributed monitoring servers
- external command interface that allows on-the-fly modifications to be made to the monitoring and notification behavior through the use of event handlers, the Web interface, and third-party applications
- retention of host and service status across program restarts
- scheduled downtime for suppressing host and service notifications during periods of planned outages
- ability to acknowledge problems via the Web interface
- Web interface for viewing current network status, notification and problem history, log file, etc.
- simple authorization scheme that allows you to restrict what users can see and do from the Web interface

1.6.2 How Nagios Works

Nagios itself is merely the aggregation portion of the entire system. In order to actually perform the checks for services, hosts, etc., Nagios relies on plug-ins.²³ The general behavior of Nagios plug-ins is analogous to that of the plug-ins you’ve come across for other software—they extend or implement functionality that is unavailable in the core program.

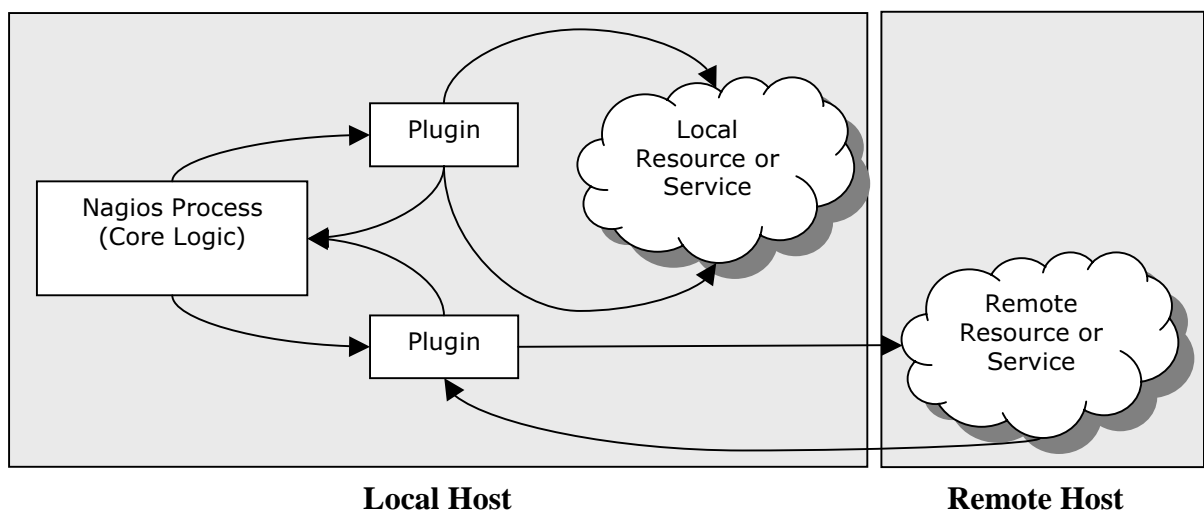


Figure 23: Nagios Plug-in Architecture

Nagios plug-ins are completely configurable in their interactions with remote processes and hosts. Also, an organization running a proprietary network service or protocol can develop its own plug-in and incorporate that into the Nagios system. Thus, there is no need to completely overhaul a Nagios installation when a new type of service or host is incorporated into the network.

²³ http://nagios.sourceforge.net/docs/1_0/plugintheory.html



Summary

Host system hardening best practices

Windows 2000 hardening techniques

Red Hat Linux hardening techniques

System monitoring tools

1.7 Summary



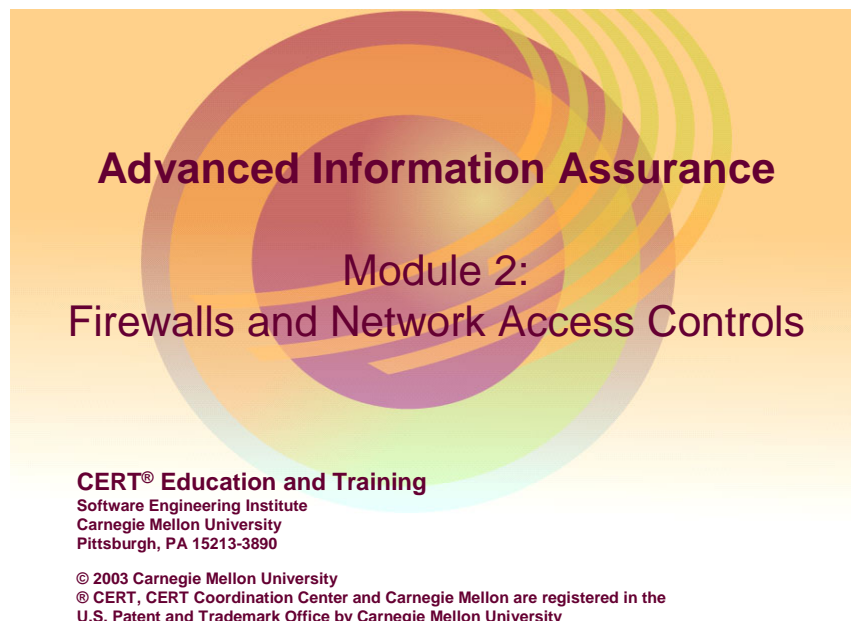
Review Questions

1. Name and describe 3 host system hardening concepts.
2. What tools can help harden a Windows IIS Web Server?
3. How can Group Policy help secure a Windows 2000 domain?
4. What directory should be inspected to see which services are loaded on a Red Hat Linux system?
5. What practice should be followed when administering rules on a host-based firewall?

1.8 Review Questions

1. Name and describe three host system hardening concepts.
2. What tools can help harden a Windows IIS Web Server?
3. How can Group Policy help secure a Windows 2000 domain?
4. What directory should be inspected to see which services are loaded on a Red Hat Linux system?
5. What practice should be followed when administering rules on a host-based firewall?

2 Firewalls and Network Access Controls



The term “firewall” is taken from the structural analog that slows the spread of fire in a building. In computer literature, the popular press, and vendor marketing materials, the term is used in many ways. Some people use it to identify a specific hardware component or software package, while others consider the entire collection of systems and software deployed as a control mechanism between two networks to be parts of a firewall.

A firewall is a combination of hardware and software used to implement a security policy governing the network traffic between two or more networks, some of which may be under your administrative control (e.g., your organization’s networks) and some of which may be out of your control (e.g., the Internet). A network firewall commonly serves as a primary line of defense against external threats to your organization’s computer systems, networks, and critical information. Firewalls can also be used to partition your organization’s internal networks, reducing your risk from insider attacks.

The term firewall has become a broad “catch-all” for systems or software that control access and packet flow between one system or network and another system or network. These systems can be appliances, built specifically for filtering the network traffic that passes through it. They can be routers configured to accept certain types of packets and to discard others. They can be software components designed to control access to a specific host. They can be a combination of any of the examples or any other type of system which controls access and filters unwanted network traffic.



Instructional Objectives

Identify systems and technologies which support access control enforcement on systems and networks

Implement a network packet filter (layers 3 and 4)

Describe the implementation of a demilitarized zone (DMZ)

Implement an application proxy which filters unwanted network traffic

Describe application layer filtering techniques

Use specific technologies to restrict access to systems and services

2.1 Instructional Objectives

Students will be able to do all of the above upon completion of this module.



Overview

- Brief review of packet filtering (static and dynamic)
- Building a DMZ and implementing filtering rules
- Implementing access control lists on a router
- Using higher layer application filtering
- Using applications for access control and filtering
- Proxy filtering
- IPSec as a network access-control mechanism

2.2 Overview

This module will cover the topics outlined above.

Commonly, network firewalls are deployed as “perimeter” security devices, located at the perimeter of a specific network or subnet. These devices are built to implement security policy by specifically allowing or denying traffic between the networks they separate. They are designed to let in good packets and keep out bad packets.

Firewalls are very good at what they do, which is to make filtering decisions based on their rules. Since these systems are designed to protect networks but are only able to make decisions based on the intelligence provided to them, the effectiveness of the firewall and the overall security of the network depend on the administration of the firewall itself, and on making, testing, and revising the rulesets the firewall uses.

Some of the firewalls we will discuss show higher “intelligence” than others. These more intelligent filters may use a variety of filtering rules across a number of criteria. They may also use connection state (stateful packet filters), packet payload (application layer filters), or other heuristic information as the filtering criteria. When it comes to packet filtering, if you can imagine it, you can likely do it!

In this module, we’ll discuss the importance of firewalls, some configuration tips, and the deployment of a variety of packet filtering techniques.



Goal of Filtering/Access Controls

Put controls in place to

- Allow or restrict access to systems/networks/services
- Limit capabilities of specific users and systems
- Keep out the bad packets wherever possible (both at the network level and at the host)

2.3 Purpose of Filtering and Network Access Controls

We're going to focus on many different technologies and practices in this module—all with the same basic goal of letting in the good and keeping out the bad. Implementing packet filters, access control rules, and access control devices will allow administrators to gain control over their network, their systems, and their services.

These tools will take many forms. Some of the technologies focus on the network layer, managing and controlling access at a choke-point on the network. Some of the technologies manage and control access on a specific host. Some of the technologies aim to be “middlemen” or brokers for applications or services, and these can manage access at a variety of positions within the network.

Despite these differences, keep in mind that all the tactics, techniques, technologies, and procedures discussed in this module share that same goal: restricting the bad traffic while allowing good traffic to pass.



Quick Review: Firewalls 101

Firewalls:

- Make packet filtering decisions on traffic based on rules
- Are often “gateways” between networks (internal and external)
- Keep unwanted traffic from entering or leaving the network it protects (can protect both ways!)
- Can be stateless (no connection state information) or stateful (keeps connection state logs)

2.4 Review of Firewalls and Packet Filtering

In the CERT Training and Education Center’s course Information Security for Technical Staff, firewalls were defined in the following terms:

- The purpose of a firewall or firewall system (which comprises one or more hosts performing specific functions) is to serve as one element of an organization’s perimeter defense. The perimeter can be defined as what separates the external network (usually the Internet) from the internal network or what separates internal sub-networks with differing access requirements. Ultimately, a firewall implements policy that specifies how network traffic is allowed to move between two or more networks. A firewall intercepts and controls traffic between networks with differing levels of trust—different security domains. A firewall is an excellent place to focus security decisions and to enforce a network security policy. In addition, firewalls can often serve as a single location where inter-network activity can be efficiently recorded/logged.
- A firewall is a highly desirable “choke point” through which all traffic should flow. As a result, it serves as a logical point for monitoring for policy compliance, examining network traffic flow and performance, detecting signs of suspicious or unexpected behavior, capturing detailed log information for later analysis, and implementing alerts for high-priority action.
- A firewall is most frequently deployed to protect an organization’s internal networks from the outside world, such as the Internet. It does so by blocking or denying both incoming and outgoing traffic that is not permitted by policy. Firewall rules and configuration need to be reviewed on a regular basis as attack patterns change frequently and new vulnerabilities are discovered almost daily.

2.4.1 Stateless and Stateful Packet Filtering

Stateless Packet Filtering

A stateless packet filter makes filtering decisions based solely on the contents of the packet it is inspecting. The stateless packet filter will review the following fields in a TCP or UDP IP datagram (where applicable):

- source address (e.g., pass in all packets from 192.168.1.0 through 192.168.1.255 but all other packets are blocked)
- destination address (e.g., packets bound for 128.162.11.14 are not permitted to pass)
- source and destination port number (e.g., all TCP packets bound for port 80 [the HTTP port] would be permitted in but TCP packets bound for ports 137-139 [NetBIOS/NetBUI] would be blocked)
- protocol type (e.g., TCP, UDP, ICMP, DECnet, IPX)
- network interface through which the packet enters
- direction of traffic (inbound or outbound)
- source routing
- fragmentation
- connection state (e.g., SYN, SYN/ACK, FIN)

Stateful Packet Filtering

Stateful packet filtering takes stateless packet filtering one step further by maintaining a connection table. The table is used to monitor the state or context of a communication session by attempting to match up outgoing and incoming packets. The information retained in the table usually includes the source and destination addresses and source and destination ports. Stateful packet filtering does not simply rely on flag settings. Every time an external packet appears to be responding to an internal request, the connection table is referenced to ensure that

- the internal host actually initiated the request
- the source port matches the originating request
- the destination port matches the originating request

A stateful packet filter may even verify that the sequence and acknowledgment numbers all match. If all this data is correct, the stateful packet filter allows the packet to pass. Once the FIN packets are sent by each system (terminating a TCP session), the connection table entry is removed. Additionally, if no reply is received for a period of time (anywhere from one minute to one hour, depending on the configuration), the firewall assumes that the remote server is no longer responding and again deletes the connection table entry. This keeps the table current, but can be an issue under certain circumstances.



Why Are Firewalls So Important?

Need for external connectivity to services creates “trust dilemma”

- What traffic is allowed to public servers?
- What users are allowed to access sensitive internal assets?
- What traffic is allowed to the protected network?
- How do we separate traffic that is allowed from traffic that is not allowed?
- Common answer: Implement a packet filter
 - Demilitarized zone (DMZ)
 - Subnets within the enterprise

2.4.2 Why Firewalls Are Important

Firewalls have grown in importance over the recent past—mainly because the enterprise has grown in both size and complexity. This larger, more complex enterprise calls for connectivity to vastly more individuals and networks than was required just a few years ago. The need to allow external connections into the enterprise creates some potentially compromising positions for the IT administrator. How can appropriate access be granted while limiting inappropriate access? How can specific systems and services be made available but be closely controlled and managed? How can malicious (and sometimes non-malicious) traffic be kept away from sensitive systems? Now more than ever, the answer lies in the development and deployment of packet filtering and network access controls. Many organizations have implemented hierarchical networks, allowing varied access to the systems in the enterprise based on where the user and system reside in the hierarchy. This requires very tight access controls.

Possibly the most common deployment of firewalls in today’s enterprise is to place them between the external network connectivity (i.e., the Internet) and the internal protected network. If public services are available through this Internet connection, it is very common for the organization to set up a demilitarized zone, or DMZ, to manage access to the service network (where the publicly available services reside) and to control access to the protected network (where the users and the remainder of the enterprise reside). The DMZ firewall essentially creates three separate networks: Internet, DMZ, and internal network. The DMZ firewall will have three network interfaces, and will apply separate rules on all three interfaces depending on the source, destination, and type of packet it receives.

Packet Filtering Rules

Almost any characteristic of a datagram at any layer can be used as a filtering “trigger”

Common filtering triggers include the following:

- Source and/or destination addresses
- Protocol (TCP, UDP, ICMP, etc.)
- Source and destination ports (TCP and UDP)
- Other TCP flags (SYN, ACK, PSH, RST, FIN, etc.)
- Packet payload
- Connection status
- If you can dream it, you can do it!

2.4.3 How Firewalls Make Packet Filtering Decisions

How do firewalls make filtering decisions? They often do so based on characteristics of the packet itself. Each packet that the firewall inspects is tested against the filtering “triggers” in the firewall’s ruleset. These characteristics often include the following:

- protocol – layer 3 or layer 4 protocol type
- interface – which network interface the packet comes in through and to which it is destined
- source address – from the IP header
- destination address – from the IP header
- source port – from the TCP or UDP header
- destination port – from the TCP or UDP header
- TCP flags – from the TCP header (these include SYN, ACK, FIN, PSH, RST, and URG)
- fragmentation – from the IP header
- connection status – for stateful packet filters, whether there is a current connection related to the packet being inspected
- packet payload – the data field within the packet
- ICMP message type – which type of ICMP message the packet is (Echo request, echo reply, destination unreachable, etc.)

Figure 24 shows the filtering abilities of the IPTables firewall running on a RedHat 9.0 system, accessed through a Webmin interface.

The action selected above will only be carried out if **all** the conditions below are met.

Condition details	
Source address or network	<Ignored> <input type="text"/>
Destination address or network	<Ignored> <input type="text"/>
Incoming interface	<Ignored> <input type="text"/> eth0 <input type="text"/>
Outgoing interface	<Ignored> <input type="text"/> eth0 <input type="text"/>
Fragmentation	<input checked="" type="radio"/> Ignored <input type="radio"/> Is fragmented <input type="radio"/> Is not fragmented
Network protocol	<Ignored> <input type="text"/> TCP <input type="text"/>
Source TCP or UDP port	<Ignored> <input type="text"/> <input checked="" type="radio"/> Port(s) <input type="text"/> <input type="radio"/> Port range <input type="text"/> to <input type="text"/>
Destination TCP or UDP port	<Ignored> <input type="text"/> <input checked="" type="radio"/> Port(s) <input type="text"/> <input type="radio"/> Port range <input type="text"/> to <input type="text"/>
Source and destination port(s)	<Ignored> <input type="text"/>
TCP flags set	<Ignored> <input type="text"/> <input type="checkbox"/> SYN <input type="checkbox"/> ACK <input type="checkbox"/> FIN <input type="checkbox"/> RST <input type="checkbox"/> URG <input type="checkbox"/> PSN out of <input type="checkbox"/> SYN <input type="checkbox"/> ACK <input type="checkbox"/> FIN <input type="checkbox"/> RST <input type="checkbox"/> URG <input type="checkbox"/> PSN
TCP option number is set	<Ignored> <input type="text"/>
ICMP packet type	<Ignored> <input type="text"/> echo-reply <input type="text"/>
Ethernet address	<Ignored> <input type="text"/>
Packet flow rate	<Ignored> <input type="text"/> / second <input type="text"/>
Packet burst rate	<Ignored> <input type="text"/>
Connection states	<Ignored> <input type="text"/> New connection (NEW) Existing connection (ESTABLISHED) Related to existing (RELATED) Not part of any connection (INVALID)
Type of service	<Ignored> <input type="text"/> Minimize-Delay (0x10) <input type="text"/>
Additional parameters	<input type="text"/>

Create

Figure 24: Webmin IPTables Firewall Filtering Options



Technologies We'll Use/Discuss

Linux/Unix

- IPChains
- IPTables
- IPFilter
- IPFirewall
- TCP Wrappers
- Snort Inline
- Squid Web Proxy

Windows

- Tiny Personal Firewall

Access Controls Points

- SSH authorized_keys

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Module 2: Firewalls and Network Access Controls–Slide 8

There are a number of technologies which we will be using to implement packet filters and network access controls. There are a variety of choices, depending on our operating systems and our desired outcome of the implementation. We will be discussing open source or freeware systems and servers in this module; some are Linux/UNIX technologies and others are for Windows 2000.

Linux/UNIX

- IPChains – a stateless packet filter present in the Linux 2.2 kernel
- IPTables – an improved version of IPChains; stateful packet inspector; present in the Linux 2.4 and later kernels; provides Network Address Translation (NAT)
- IPFilter – stateful packet filter for the BSD/UNIX environment; provides NAT
- IPFirewall - stateful packet filter for the BSD/UNIX environment; provides NAT
- TCP Wrappers – an application which manages connections to specific services on a Linux/UNIX system
- Squid and SquidGuard – a Web proxy and proxy filter for Linux
- Snort Inline – an application layer filter for Linux

Windows 2000

- Tiny Personal Firewall – a host-based firewall
- IPsec – a suite of protocols that encrypt network traffic between hosts or networks and provide filtering capabilities



IPTables—How It Works

IPTables has a series of 3 tables, each of which contains some “chains:”

- Filter Table – Makes the filtering decisions
- NAT Table – Performs NAT functions
- Mangle Table – Modifies packet headers (only ToS and TTL)



IPTables—How It Works - 2

IPTables has a number of built-in “chains” that get called to inspect a packet.

- Input Chain – Handles traffic destined for firewall
- Output Chain – Handles traffic from firewall
- Forward Chain – Handles traffic that crosses FW
- Prerouting Chain – Destination NAT operations
- Postrouting Chain – Source NAT and masquerade operations

Administrators can create user-defined chains to do almost anything else.

2.5 IPTables (Netfilter for Linux)

IPTables, sometimes known as Netfilter for Linux, is a very powerful stateful inspection firewall. The nomenclature of IPTables can be a little confusing, so it’s worth some time to enumerate some of the key features and functions.

IPTables has a set of “chains,” which are so named because IPTables is a descendent of IPChains, an older stateless firewall for Linux systems. IPTables consists of a number of tables, each of which contains specific chains that are called to make packet filtering and

forwarding decisions for each packet the IPTables firewall inspects. Table 1 shows the tables included in the IPTables firewall, as well as their associated chains and functions.

Table 1: Tables Included in the IPTables Firewall and Their Associated Chains

Tables in IPTables	Associated “chains” included in the table
Filter	<p>FORWARD – handles packets which cross the firewall (from one network interface to another)</p> <p>INPUT – handles packets destined for the localhost (i.e. the system running the firewall)</p> <p>OUTPUT – handles packets which originate from the localhost and are outbound</p>
NAT	<p>PREROUTING – performs destination network address translation (does not do packet filtering). Modifies destination IP and/or destination port.</p> <p>POSTROUTING – performs source NAT and masquerading. Modifies source IP and/or source port.</p>
Mangle	<p>PREROUTING – seldom used; allows for changing of TTL and ToS to mark packets</p>
	<p>User-defined Chains – administrators can set up their own chains which must be tied to one of the tables. Packets can be sent to a user chain if a special ‘target’ is hit by the packet during inspection. For example, a user could create a user chain called ‘CHAIN_TEST’ that can have a number of subsequent rules which the packet must be evaluated against the rules in the CHAIN_TEST chain as well. An example might be:</p> <p>In the FORWARD chain, there is a rule which looks for a specific set of TCP flags (SYN, RST, PSH). If these flags are all set, the packet may be sent to the CHAIN_TEST chain, which will do a further inspection of the packet based on rules which are specific to those TCP flags. If the packet meets the requirements to be acceptable to the CHAIN_TEST chain, it will then call the RETURN target which will pass it back to the FORWARD chain.</p> <p>Creating and administering user chains is a very effective way to manage very large rule sets on a firewall, as only packets which meet certain requirements will be passed on to these user defined chains.</p>

IPTables is made up of a series of tables containing chains, which in turn contain rules which specify targets. A target is what happens to a packet when a rule is met (dropped, accepted, logged, sent to another chain, etc.).

Some Example Rules - IPTables

The screenshot shows the 'Linux Firewall' configuration window. At the top, there's a 'Showing IPTable:' dropdown set to 'Packet filtering (filter)' and a button 'Add a new chain named:'. Below this, the 'Incoming packets (INPUT)' section contains a table with two rules:

Action	Condition	Move	Add
Accept	If protocol is TCP and destination is 192.168.232.2 and destination port is 10000	↓	↓ T
Accept	Always	↑	↓ T

Below the table are buttons for 'Set default action to: Accept', 'Clear all rules', and 'Add rule'. The 'Forwarded packets (FORWARD)' section states 'There are no rules defined for this chain.' and has a button 'Add rule'. The 'Outgoing packets (OUTPUT)' section contains a table with one rule:

Action	Condition	Move	Add
Accept	If source is 192.168.232.2		↓ T

Below this table are buttons for 'Set default action to: Accept', 'Clear all rules', and 'Add rule'.

Demo: IPTables Rules

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2.5.1 IPTables Rules

Now we'll examine a few specific IPTables rules and see exactly what they are doing to the packets they inspect.

We want to create a rule which will allow Webmin access from one specific host to our firewall. This host, 192.168.93.1, will be the only system that will be allowed to send Webmin packets to our firewall.

Webmin operates on TCP port 10000. Therefore, we want to go to our Webmin client and create the rules which will allow only this host to connect on TCP port 10000 (see Figure 25).

Chain and action details	
Part of chain	Incoming packets (INPUT)
Rule comment	Webmin Access
Action to take	<input type="radio"/> Do nothing <input checked="" type="radio"/> Accept <input type="radio"/> Drop <input type="radio"/> Userspace <input type="radio"/> Exit chain <input type="radio"/> Run chain

The action selected above will only be carried out if **all** the conditions below are met.

Condition details	
Source address or network	Equals 192.168.93.1
Destination address or network	Equals 192.168.93.2
Incoming interface	<Ignored> eth0
Outgoing interface	<Ignored> eth0
Fragmentation	<input checked="" type="radio"/> Ignored <input type="radio"/> Is fragmented <input type="radio"/> Is not fragmented
Network protocol	Equals TCP
Source TCP or UDP port	<input type="radio"/> <Ignored> <input checked="" type="radio"/> Port(s) <input type="radio"/> Port range
Destination TCP or UDP port	Equals Port(s) 10000 <input type="radio"/> Port range
Source and destination port(s)	<Ignored>
TCP flags set	<input type="checkbox"/> SYN <input type="checkbox"/> ACK <input type="checkbox"/> FIN <input type="checkbox"/> RST <input type="checkbox"/> URG <input type="checkbox"/> PSH out of <input type="checkbox"/> SYN <input type="checkbox"/> ACK <input type="checkbox"/> FIN <input type="checkbox"/> RST <input type="checkbox"/> URG <input type="checkbox"/> PSH
TCP option number is set	<Ignored>

Figure 25: Allowing TCP Port 10000 Inbound from 192.168.93.1/32.

The second rule will allow packets with a source TCP port of 10000 back to 192.168.93.1/32 (see Figure 26).

Chain and action details	
Part of chain	Outgoing packets (OUTPUT)
Rule comment	Webmin Out
Action to take	<input type="radio"/> Do nothing <input checked="" type="radio"/> Accept <input type="radio"/> Drop <input type="radio"/> Userspace <input type="radio"/> Exit chain <input type="radio"/> Run chain

The action selected above will only be carried out if **all** the conditions below are met.

Condition details	
Source address or network	Equals 192.168.93.2
Destination address or network	Equals 192.168.93.1
Incoming interface	<Ignored> eth0
Outgoing interface	<Ignored> eth0
Fragmentation	<input checked="" type="radio"/> Ignored <input type="radio"/> Is fragmented <input type="radio"/> Is not fragmented
Network protocol	Equals TCP
Source TCP or UDP port	<input type="radio"/> Equals <input checked="" type="radio"/> Port(s) 10000 <input type="radio"/> Port range
Destination TCP or UDP port	<input type="radio"/> <Ignored> <input checked="" type="radio"/> Port(s) <input type="radio"/> Port range
Source and destination port(s)	<Ignored>
TCP flags set	<input type="checkbox"/> SYN <input type="checkbox"/> ACK <input type="checkbox"/> FIN <input type="checkbox"/> RST <input type="checkbox"/> URG <input type="checkbox"/> PSH out of <input type="checkbox"/> SYN <input type="checkbox"/> ACK <input type="checkbox"/> FIN <input type="checkbox"/> RST <input type="checkbox"/> URG <input type="checkbox"/> PSH
TCP option number is set	<Ignored>

Figure 26: Setting Outbound Restrictions to Port 10000; Destination to 192.168.93.1

The final step is to create the “Deny All” for both incoming and outgoing packets (see Figure 27). This will cause any packet which does not meet our ruleset to be dropped.

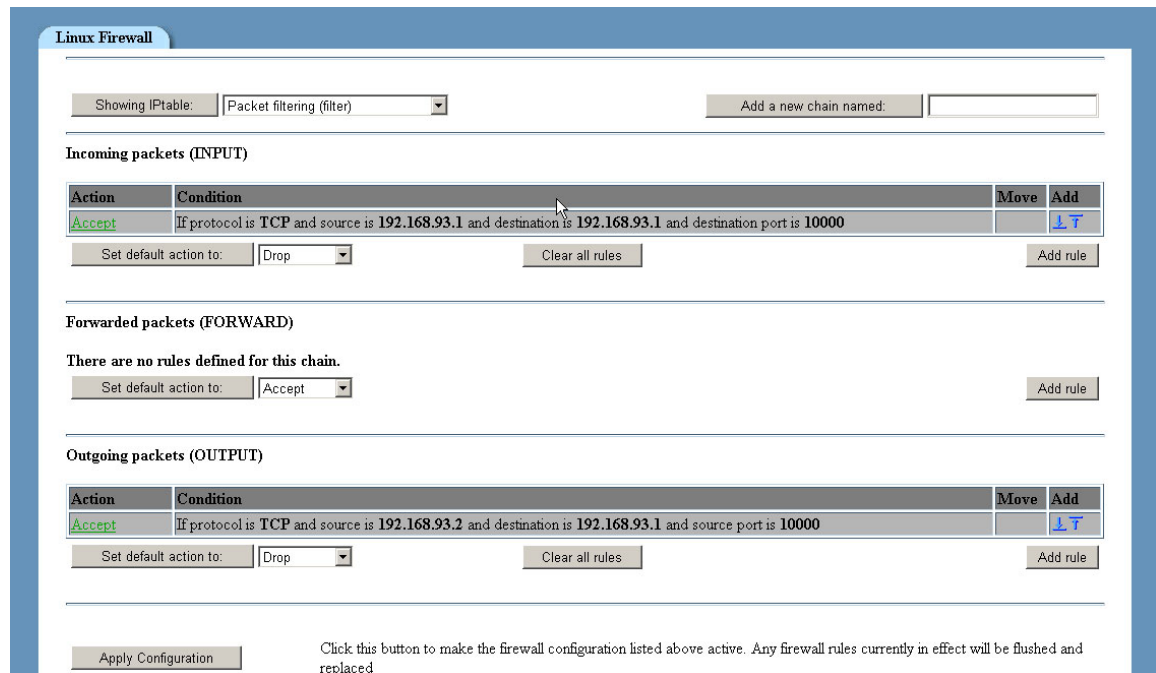


Figure 27: Creating Implicit “Drop” for Incoming and Outgoing Packets

After applying the configuration, we have a packet filter which will only allow inbound connections to Port 10000 from one host: 192.168.93.1.

The result of attempting to ping the Webmin firewall host (ping 192.168.93.2) is shown in Figure 28:

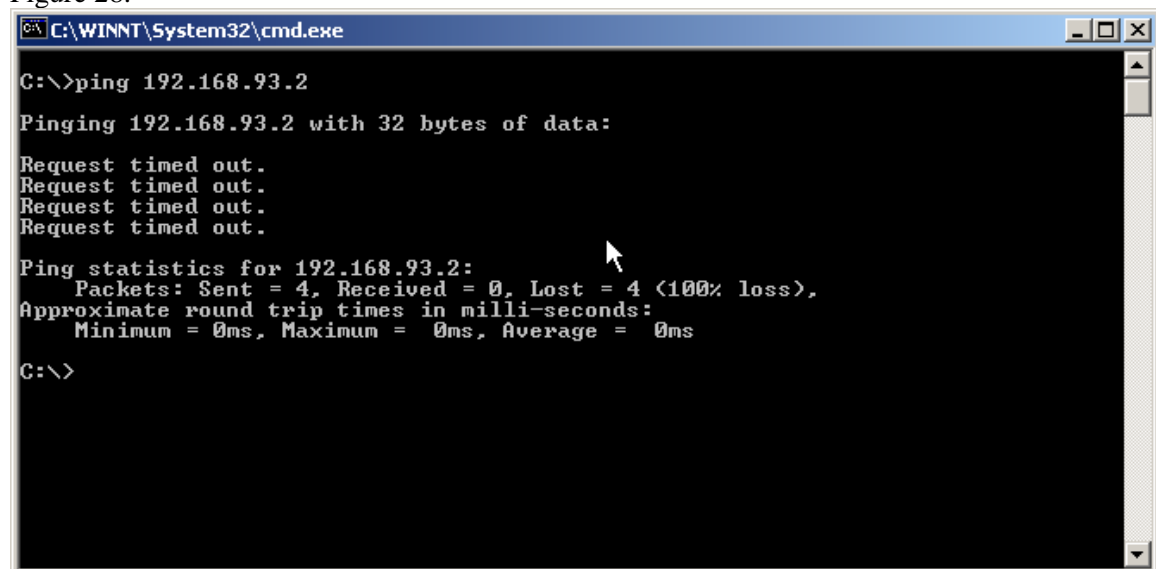
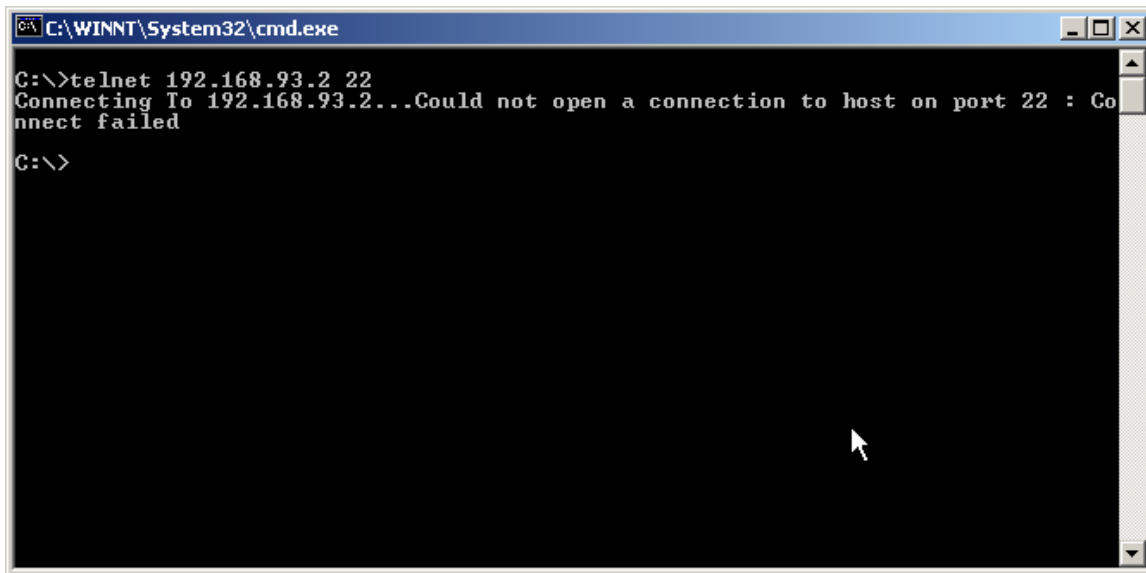


Figure 28: Pinging the Webmin Firewall Host

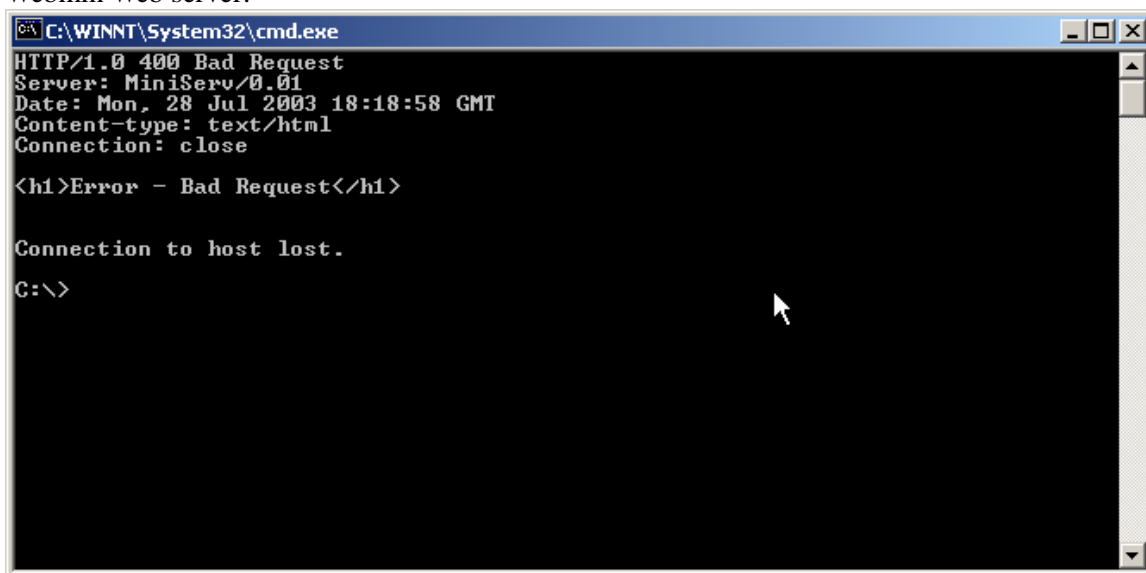
The result of telnetting to the ssh port (telnet 192.168.93.2 22), which is running on the system, is shown in Figure 29:



```
C:\WINNT\System32\cmd.exe
C:\>telnet 192.168.93.2 22
Connecting To 192.168.93.2...Could not open a connection to host on port 22 : Co
nnect failed
C:\>
```

Figure 29: Telnetting to the SSH Port

The result of telnetting to port 10000 (telnet 192.168.93.2 10000) is shown in Figure 30, in which we can see that a connection was made but not understood by the Webmin Web server:



```
C:\WINNT\System32\cmd.exe
HTTP/1.0 400 Bad Request
Server: MiniServ/0.01
Date: Mon, 28 Jul 2003 18:18:58 GMT
Content-type: text/html
Connection: close
<h1>Error - Bad Request</h1>
Connection to host lost.
C:\>
```

Figure 30: Telnetting to Port 10000

We have effectively limited the access to this system based on our firewall rules, allowing only one specific port (TCP port 10000) to one specific host (192.168.93.2/32).



Practical Firewall Example: DMZ

A DMZ will do the following:

- Allow acceptable inbound packets from the Internet to the public servers (which are in the DMZ)
- Block unacceptable inbound packets from the Internet to the public servers
- Block all inbound packets from the Internet to the protected network
- Allow acceptable packets from the protected network to the DMZ; block unacceptable packets
- Allow acceptable packets from the DMZ to the protected network
- Route all packets between the networks as required

2.6 Demilitarized Zones (DMZs)

Creating the demilitarized zone, or DMZ, is often the responsibility of the external firewall in any given enterprise. A DMZ is your front line when protecting valuables from direct exposure to an untrusted environment. SI Security defines a DMZ as “[a] network added between a protected network and an external network in order to provide an additional layer of security” [SSI 03]. A DMZ is sometimes called a “perimeter network” or a “three-homed perimeter network.”

If you don’t have a DMZ and your initial frontline perimeter is compromised, then the game is up. Even if you have hardened your operating system and have a firewall, there is still the possibility that the software on those systems might contain a bug that an attacker could exploit. New bugs are found all the time in software. When you consider all the IIS bugs, sendmail bugs, and DoS attacks, you realize that it may only be a matter of time until your initial perimeter is violated. Then the attacker has access to whatever vital information you have on those systems, such as your protected files and databases. A DMZ hides your important information an extra step away from an attacker.

2.6.1 Preparation and Implementation for DMZs

To create the rules which will allow us to put a DMZ into place, we need to go through the following steps in the preparation and implementation phases:

1. *Determine what services will be in the DMZ.* Will the DMZ contain Web servers? Mail servers? DNS? It is important when planning for the DMZ to identify all services which

will reside within that network. At this point, it is important to consider whether the services will be offered on standard service ports or on non-standard ports.

2. *Who needs access to these services?* Will all of the services be publicly available? Will they be available only to a select set of users from the Internet? Will they be available only from the internal corporate network?
3. *How will the DMZ and protected network be protected?* What technologies will be deployed to segregate the DMZ from the Internet? What technologies will be deployed to protect the internal network?
4. *Create rulesets for the packet filter(s).* Once the administrator knows what services will be offered from the DMZ to the Internet and the internal network, it is time to build the ruleset(s) for the firewall(s). This will include determining what traffic is legitimate in each direction, from each network to each interface. This sounds confusing at first, but consider the following list of rulesets which must be written:

Table 2: Rulesets That Must Be Written for Packet Filter(s)

Source Network	Destination Network	Valid Traffic
Internal network	DMZ	?
DMZ	Internal network	?
Internet	DMZ	?
DMZ	Internet	?
Internal network	Internet	?
Internet	Internal network	?

Once the packet allow/deny rules are documented completely, it's time to put them in place on the firewall. For most implementations, this is the point at which we will create rulesets on the firewall that allow "legitimate" packets and drop the rest according to the deny all rule—the rule that denies any request not specifically allowed. (Most administrators add this rule after all of the "allow" rules have been built.)

5. *Test the packet filter(s).* After the rules are built, it's important to test the firewall to ensure that valid traffic is allowed and all other traffic is denied.

Exercising your installation and configuration procedures in a test environment will minimize the impact on your operational systems while you learn the requirements for efficient installation and configuration of both the operating system and your firewall software. It will also highlight any hardware that may be missing in your initial configuration.

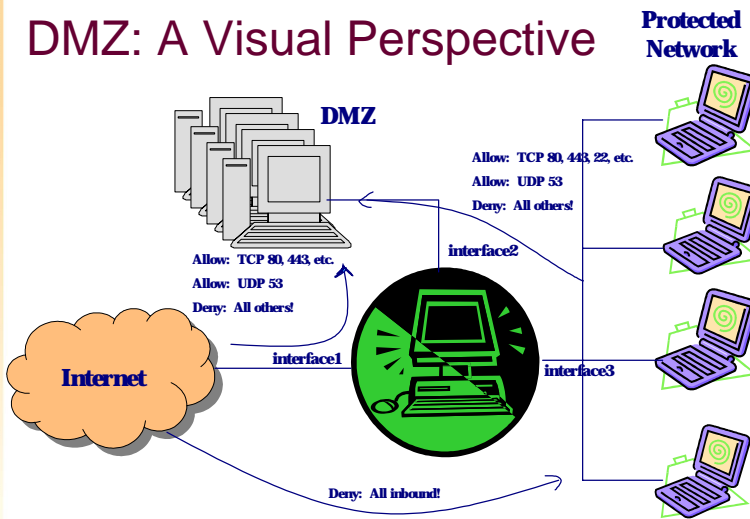
Establish a test configuration in which your firewall system is interconnected between two isolated hosts, one playing the role of the external world and the other playing the role of your internal hosts. Ensure that the default gateway for the internal host is set to the firewall system under test. If you have implemented a central log host, place both the internal host and a log host on your internal network so that you can test logging options. If logging is performed on the firewall host, you can connect the internal host directly to the firewall host. Have scanning or network sniffing tools in place on your outside and inside hosts to capture all traffic in both directions (inside to outside and outside to inside).

Setting up a Test Environment for Packet Filters

- i Disable packet filtering.
- ii Inject packets that will exercise all routing rules and send these through the firewall system.
- iii Ensure that packets are routed correctly by examining the firewall logs and your packet sniffer results.
- iv Turn on packet filtering.
- v Inject network traffic that is an appropriate sampling of all possible source and destination IP addresses, across all ports, and for all protocols.
- vi Ensure that packets intended to be blocked (denied) are blocked. For example, if all UDP packets are to be blocked, ensure that none get through. Ensure that packets intended to enter or exit (permitted) do enter and exit. Do this by examining your firewall logs and scanner results.
- vii Ensure that packets intended for proxy handling are sent to the correct proxy and forwarded correctly.
- viii Scan for open and blocked ports to ensure your firewall system is performing as intended.
- ix Examine all of the network traffic that is logged and verify that the logging options associated with each packet filtering rule are operating as intended.
- x Examine all of the network traffic that is logged and verify that the alert options associated with each logging option are sending alerts to the designated destination (such as the firewall administrator) using the specified mechanism (such as paging or email).
- xi Test logging capabilities.
- xii Test failure mode (i.e. failing closed or failing open).

6. *Deploy the packet filter(s).*

DMZ: A Visual Perspective



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2.6.2 Graphical Representation of a DMZ

The diagram in the slide above graphically depicts the construction of a DMZ which is set up to allow access to a few specific services to the Internet—in this case, Web (80 and 443 for secure and standard http traffic) and DNS for name resolution (UDP port 53). It is set to deny all inbound connections from the Internet to the protected network, and to only allow TCP port 22 for SSH from the internal network to the DMZ (for management) in addition to the other ports open to the Internet.

DMZ Tricks

Limit connection requests inbound to “reasonable” number

- Can block SYN floods

Allow management traffic from only “acceptable” networks (i.e., management network)

Use higher layer filters

Demo: Connection Limiting

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2.6.3 Recommended DMZ Configurations

There are a number of configurations that will help ensure a more secure DMZ when the firewall is implemented. These include the following:

1. *For servers offering public services, limit the number of inbound connection requests within a given time interval.* Using the firewall to block these inbound connection requests (after the threshold is met) can help to avoid SYN floods. In a SYN flood, a system or systems send a number of SYN packets to the server in the DMZ. Since the system keeps a connection half open after sending a SYN-ACK while it waits for the ACK from the client, this can lead to resource exhaustion (servers can have only a finite number of half open connections before there’s no way to open more). A firewall can be configured to drop packets after the threshold is reached in the allotted time. In Figure 31, you can see the Webmin interface displaying an example rule from IPTables that limits inbound ICMP exho requests from the 192.168.0.0/16 network to the firewall host to 10 per second (for illustrative purposes). The firewall will drop packets which match this rule if the flow rate exceeds 10 per second.

Incoming packets (INPUT)

Action	Condition	Move	Add
Accept	If protocol is ICMP and source is 192.168.0.0/16 and destination is 192.168.3.1 and rate is less than 4/second		↓ ↑
Set default action to: Drop		Clear all rules	
		Add rule	

Figure 31: Example Rule from IPTables as Displayed by Webmin

Figure 32 shows some ICMP traffic destined for the firewall (many pings were running in this case in multiple windows) showing that some of the packets were dropped when the flow rate exceeded 4 per second.

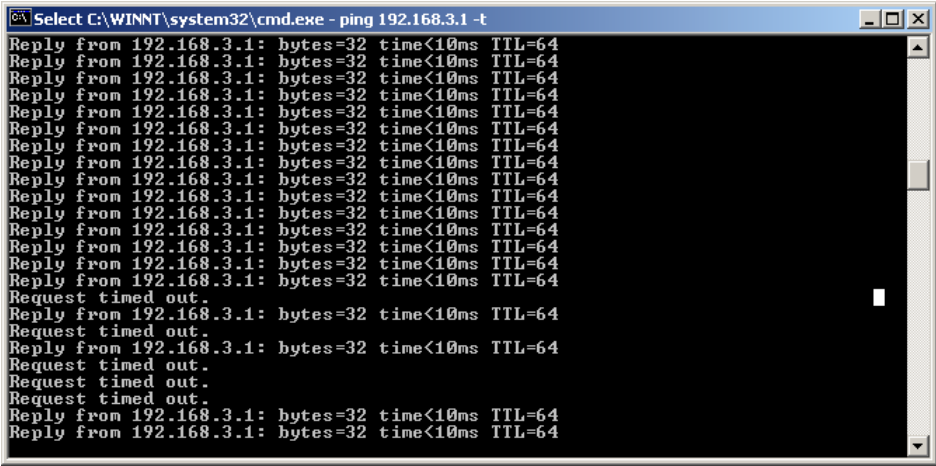


Figure 32: ICMP Traffic Destined for the Firewall

2. *Management traffic to the DMZ should likely only come from the management network (provided one exists).* This includes any type of management traffic which will be used to manage the hosts in the DMZ. In our case, we'll assume all management of Web servers, DNS, etc. will be done either via the Webmin interface (TCP Port 10000) or via SSH (TCP Port 22). We'll write some rules to allow only these into the DMZ from the management network (in this case 192.168.2.0/24). Figure 33 shows the ruleset:

Action	Condition	Move	Add
Accept	If protocol is TCP and source is 192.168.2.0/24 and destination is 192.168.2.11 and input interface is eth0 and destination port is 10000	↓	↓ ↑
Accept	If protocol is TCP and source is 192.168.2.0/24 and destination is 192.168.2.11 and input interface is eth0 and destination port is 22	↑	↓ ↑

Set default action to: Drop
Clear all rules
Add rule

Figure 33: Ruleset for Management Traffic from Management Network to the DMZ

We will discuss technologies later in this section that do higher layer filtering, inspecting the contents of the packet payload for all inbound and outbound packets, which can be used as rudimentary intrusion prevention systems. This is a DMZ trick we'll describe later.

Routers as Packet Filters

- Nearly all routers can implement filtering rules
- Often stateless (since routers are built to route)
- Very useful for ingress/egress filtering
- Less useful for true “firewalling”

2.7 Routers

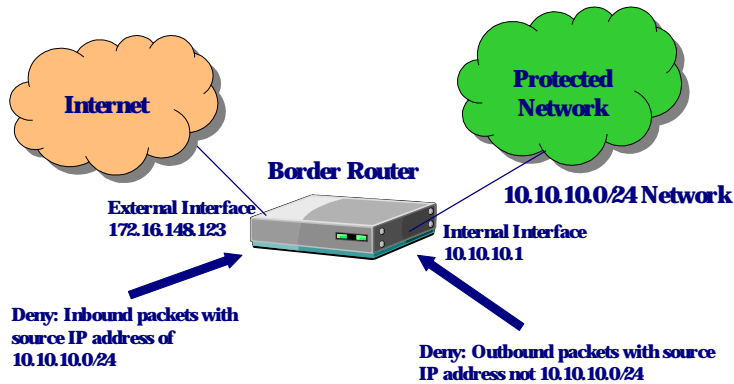
2.7.1 Routers as Packet Filters

Besides the appliance or specialty firewalls, there are a number of infrastructure components that can be set up to do packet filtering and access control management. Routers certainly have this ability. They are capable of inspecting the packets they are routing and making routing decisions based on all the header information at layers 3 and 4. Of course, one of these routing decisions could be to simply drop the packet. They lack the resources to create and manage the state tables that stateful inspection firewalls can, but this only makes sense: routers are built to route traffic, not to be firewalls.

Therefore, routers can be effective stateless packet filters, but they don’t offer the security protection that stateful inspection firewalls do and should be used as stand-alone network firewalls only in rare cases, on small networks with relatively small throughput on their bandwidth. Some organizations put all of their packet filtering capabilities within the router, asking their routers to both route and act as firewalls. This is generally considered a bad network administration practice.

Routers are excellent, however, for implementing ingress and egress filtering. We’ll look at ingress and egress filtering on the next slide.

Ingress/Egress Filtering Example



Demo: Cisco Filtering ACLs

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2.7.2 Ingress and Egress Filtering

There are a lot of bad packets out there—malicious, malformed, and sometimes nasty. Therefore, administrators need to be wary of what they are letting into and out of their networks. Implementing ingress and egress filtering is a perfect way to be a good Internet citizen and to protect your network (and yourself) from some potentially malicious traffic.

Ingress means “to enter” and egress means “to exit.” We are going to make sure that packets entering and leaving our network pass some common sense rules tied to their source and destination addresses. These common sense rules include the following:

- *Do not allow outbound traffic through your external gateway if the source address is not on your network.* In other words, if you have the 10.10.1.0/24 network address space behind the gateway router, there should never be any packets outbound which have a source address of anything but 10.10.1.0/24. Any packets with a source address outside this range that are destined for a remote network should be discarded, as they are likely spoofed or malformed. Either way, they should not be allowed to pass through the gateway router.
- *Do not allow inbound traffic through the gateway if the source address is on your own network IP space.* In the above example, if your public IP space is the 10.10.1.0/24, there should not ever be packets coming from the remote network which have a source address of your internal IP space. These are also likely spoofed or malformed packets.

Application Filtering and Access Controls

Many applications allow filtering rules to be applied

TCP Wrappers “wraps” inetd services (ftp, telnet, etc.)
`/etc/hosts.allow`

Services like SSH allow access control lists (ACLs)
`~/.ssh/authorized_keys`

Demo: SSH Host Filtering

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2.8 Application Filtering and Access Controls on Individual Hosts

In the event that we cannot control access with packet filters on the network, it is possible to control access to systems and services by implementing filtering and access control rules on individual hosts. This practice was especially common in the days before the growth of firewalls in the enterprise and still offers some distinct advantages, including tying access controls to services as a form of authentication, independently of or in conjunction with their network addressing information. Properly configuring and deploying such access controls can increase the security offered by firewalls or other packet filters for systems and services on the network.

2.8.1 TCP Wrappers

One very common implementation of application filtering is installed by default with many implementations of Linux/UNIX: TCP Wrappers, also known as *tcpd*. This program is designed to stand between an incoming request and the requested service. Many modern network services, such as SSH, Telnet, and FTP, can be configured to use TCP Wrappers as a means of authenticating users to their services. The idea behind TCP Wrappers is that client requests to server applications are “wrapped” by an authenticating service, allowing a greater degree of access control and logging of who is attempting to use the service, rather than the usual method of direct client connections to a service.

When a user attempts to gain client access to a network service that is using TCP Wrappers, a small wrapper program reports the name of the service requested and the client's host information. The wrapper program does not directly send any information back to the client.

After the access control directives are satisfied, the wrapper is unloaded, freeing any resources associated with it. The client and the server can then resume actions without further wrapper intervention.

TCP wrappers provide two basic advantages over other network service control techniques:

1. *The connecting client is unaware that TCP wrappers are in use.* Legitimate users will not notice anything different, and attackers never receive any additional information about why their attempted connections have failed.
2. *TCP wrappers operate separately from the applications the wrapper program protects.* This allows many applications to share a common set of configuration files. It is much simpler to manage this type of setup than one in which each service has its own access control method.

2.8.2 Application-Based Authentication and Filtering with Various Applications

Rlogin, POP3, and FTP

Here's an example of an `/etc/hosts.allow` file, showing what users and/or addresses are allowed to connect to specific services:

```
rlogin : magnesium chlorine calcium iron
pop3 : .aia.com EXCEPT mailhost.aia.com
ftpd : 192.168.4 192.168.10
```

The first entry grants access to the `rlogin` service to users on any of the listed hosts (hostnames may be separated by commas or spaces). The second entry allows email retrieval via POP3 by users from any host in the domain `aia.com` except `mailhost`. The third entry allows `ftp` access to all hosts on the subnets `192.168.4` and `192.168.10`.

Secure Shell (SSH)

It is very common to use application-based filtering for the secure shell, or SSH. SSH, which operates on TCP Port 22, can be configured for a wide variety of application-based authentication and filtering rules including the following:

- IP address
- users (allowed and denied explicitly)
- public key (authenticates users only if they have the appropriate key)

You can use a variety of other access control mechanisms for many services. For the secure shell, there are a number of options. It can be compiled with support for TCP Wrappers, and managed through the `/etc/hosts.allow` file. It can also use access-controls based on public key, as we'll demonstrate here. This example shows how to create a `~/.ssh/authorized_keys` file

for a user and then populate that file with the public key for that particular user. This allows the administrator to limit access to a user based on the user's possession (physical possession) of the public key stored in the `~/.ssh/authorized_keys` file. Although this system requires that users take their public keys with them when they intend to log in remotely, that is what makes it a very strong method of authentication: it can be configured to allow users to log in only if they have that 1024 bit (or longer) key they generated.

Setting up Public-Key Authentication Between an OpenSSH Client and an OpenSSH Server

1. Generate a key if necessary:

```
localhost$ mkdir -p ~/.ssh
$ chmod 700 ~/.ssh
$ cd ~/.ssh
$ ssh-keygen -t dsa
```

*If it doesn't
already exist*

2. Copy the public key to the remote host:

```
$ scp -p id_dsa.pub remoteuser@remotehost:
Password: *****
```

3. Log into the remote host and install the public key:

```
$ ssh -l remoteuser remotehost
Password: *****
```

```
remotehost$ mkdir -p ~/.ssh
remotehost$ chmod 700 ~/.ssh
remotehost$ cat id_dsa.pub >> ~/.ssh/authorized_keys
remotehost$ chmod 600 ~/.ssh/authorized_keys
remotehost$ mv id_dsa.pub ~/.ssh
remotehost$ logout
```

*If it doesn't
already exist*

Appending

*Optional—
just to be
organized*

4. Log back in via public-key authentication:

```
$ ssh -l remoteuser remotehost
Enter passphrase for key '/home/smith/.ssh/id_dsa': *****
```

ACLs for Specific Services

```
[root@vader etc]# cat /etc/xinetd.d/telnet
# default: on
# description: The telnet server serves telnet sessions; it uses \
# unencrypted username/password pairs for authentication.
service telnet
{
    flags = REUSE
    log_on_failure += USERID
    socket_type = stream
    user = root
    server = /usr/sbin/in.telnetd
    wait = no
    only_from = 192.168.3.99
}

[root@vader etc]#
```

Demo: xinetd ACLs

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2.8.3 Configuring Built-In Access Controls in Services

Many services are configurable to include various types of access controls in their configuration files—even without implementing TCP Wrappers. For example, the telnetd service, part of the extended Internet daemon services (xinetd), can be configured to implement access controls when the service is started. This can be done by simply editing one configuration file, in this case `/etc/xinetd.d/telnet`, to include network addresses which should be allowed.

The following services can be configured through the same process of editing the appropriate configuration file from the `/etc/xinetd.d/` directory:

- chargen
- daytime-udp
- ntalk
- rsync
- telnet
- chargen-udp
- echo
- rexec
- servers
- time
- cups-lpd
- echo-udp
- rlogin
- services
- time-udp
- daytime
- finger
- rsh
- talk
- wu-ftpd

Packet Filtering Above Layer 4

New intrusion prevention systems work above layer 4 for packet filtering decisions

Can filter based on packet payload

Can be combined with other filtering techniques for very strong access controls

Can work for all types of packets (inbound, outbound, etc.)

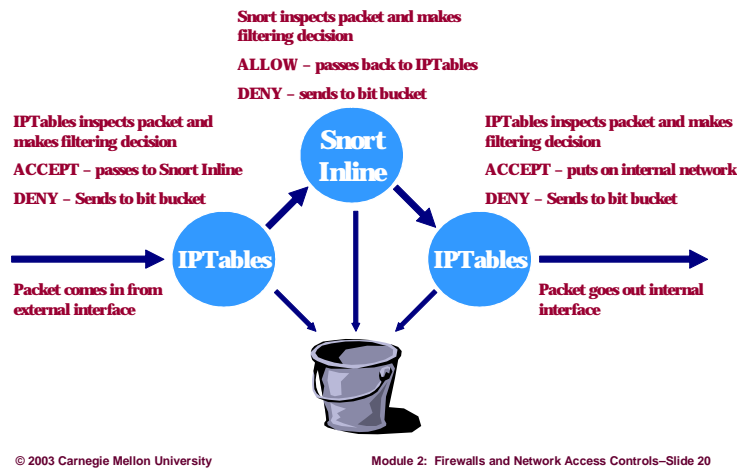
2.9 Packet Filtering Above Layer 4

Most of the packet filtering decisions we've discussed so far have been based primarily on the contents of the IP header, the TCP/UDP header, and the ICMP fields. These filtering rules are focused on layers 3 and 4. But sometimes there are “bad” packets which look completely “good” at layers 3 and 4. Numerous worms in the recent past, such as Code Red, Nimda, and Code Red II, have taken advantage of servers which *must* be allowed to listen on their service ports (Web servers listening on port 80, SQL servers listening on port 1412, etc.). These packets, based on the filtering we've covered to this point, *must* be able to reach their intended victims. Remember, HTTP get packets from the Internet must reach port 80 on your Web server—otherwise, you don't have a publicly available service!

If we know that there are some types of malicious packets out there that could reach our systems despite our layer 3 and 4 filtering rules, can't we do some inspection of the packet payload itself to try to determine whether it is a good packet or a bad packet? The answer is yes. There are emerging technologies which can be configured to act as packet filters, making their filtering decisions by inspecting the packet payload and doing signature matching—dropping packets with payloads containing signatures that it has identified as bad.

It's important to point out that much of this technology is in its infancy. Although the packet filters and access controls evolving in this area are definitely “works in progress,” they have great potential as precursors to a true “intrusion prevention system”—one which makes intelligent decisions based on substantially more information than is available to current packet filtering technologies.

Higher Layer Packet Filtering with Snort Inline



2.9.1 Snort-Inline

Snort-Inline is more or less a Snort binary that can be configured to receive specific input from IPTables. IPTables inspects the packets and, if they pass all of IPTables' filtering rules, passes them to the Snort engine. Snort is usually used simply as a signature-based intrusion detection system (IDS), which will alert when patterns are matched but do nothing else. It has been modified recently to inspect packets from IPTables after accepting them, looking for signatures defined in the Snort configuration files. Snort-Inline can do a number of things to the packets based on the packet signatures and Snort rules:

- drop a packet if it matches a rule
- modify a packet (changing normally “harmful” packets to benign ones)
- pass a packet back to IPTables for further inspection and subsequent forwarding to the destination network
- log any of the above

The next figures illustrate paths taken by a couple of packets that encounter a Snort-Inline system. Figure 34 shows a packet that is dropped by the system, and Figure 35 shows a packet that is modified by Snort-Inline.

Snort-Inline Mode

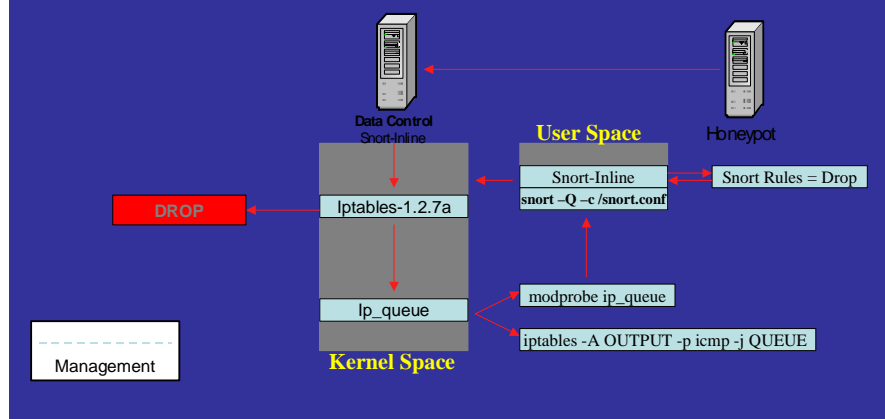


Figure 34: Packet Dropped by Snort Inline System

Figure 35 shows a command changed from `/bin/sh` to `/ben/sh` which will cause this exploit script to be unsuccessful.

Snort-Inline Replace Mode

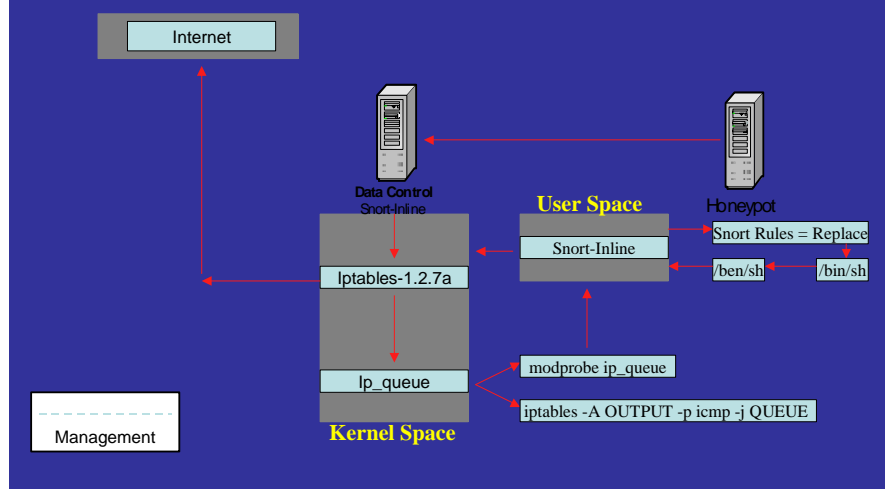


Figure 35: Packet Modified by Snort Inline System

So how is Snort-Inline an intrusion prevention system, and how can it work to filter traffic destined for your network? It uses technology not yet used in packet filtering—inspection of the complete payload and signature to check whether the packet matches any known malicious packets. While this will be unsuccessful at stopping “Zero Day” attacks (those which have not been seen before and for which there is not a signature), it can be configured to stop malicious packets with known signatures (Code Red, Nimda, SQL Slammer, etc.) from wreaking havoc on your network or others’ networks.

IPSec and Access Controls

Creation of IPSec SAs on the network can act as an “access control” mechanism.

Allow only IPSec encrypted traffic between hosts on a network.

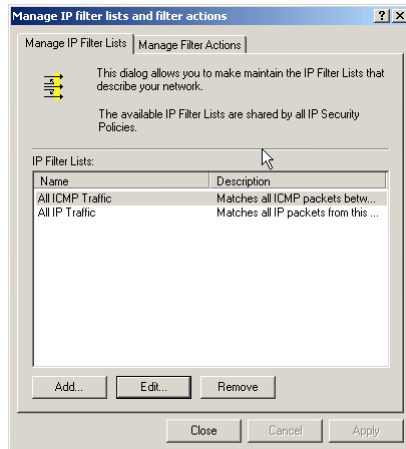
- Hosts drop all non-IPSec packets
- Match network and encryption configurations or packets are dropped

2.9.2 IPSec Access Controls

Earlier, when we were concerned solely with encryption, we successfully deployed IPSec to the local network. Because of some features in the IPSec implementations on most operating systems, we can configure our IPSec client settings to do packet filtering and network access control functions on our own host.

This is done through IPSec filtering rules. It is possible in IPSec deployments to require that all traffic destined for specific hosts be encrypted with IPSec, and that all traffic which is not encrypted with IPSec should be dropped. This effectively sets up access controls, allowing for only valid IPSec connections (through IPSec secure associations). We’ll go through some steps to see how this is done on a Windows 2000 Professional client system. These principles can be extended to servers as well, and would be effective wrappers for connections between clients and servers. The IPSec tunnels would themselves be responsible for a great deal of authentication and access controls, and would offer a greater level of certainty that only allowed hosts were communicating with each other.

Creating IPsec Access Controls



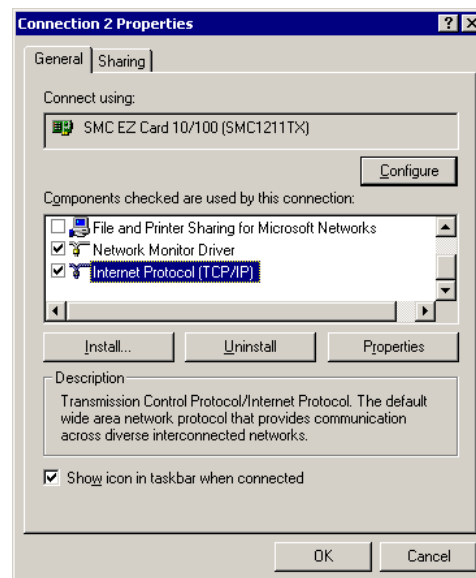
Demo: IPsec Filtering

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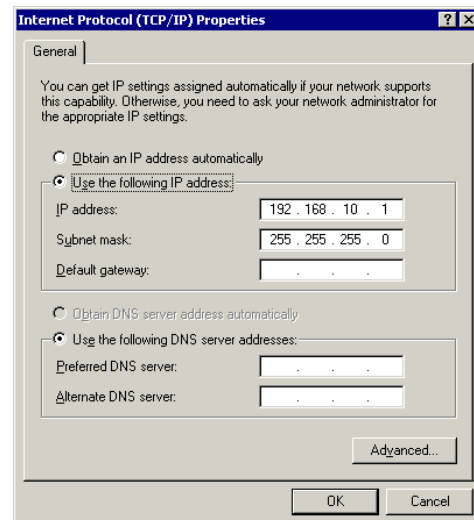
Module 2: Firewalls and Network Access Controls—Slide 22

Configuring a Computer Running Windows 2000 Professional to Use IPsec

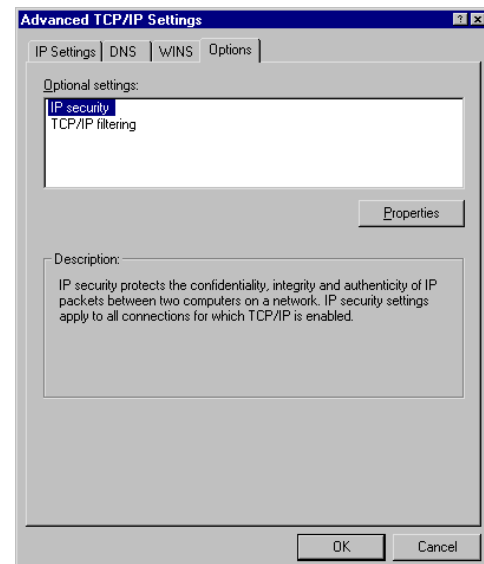
1. Open the TCP/IP properties sheet for the network connection over which you want to use IPsec. (This must be a connection that uses the TCP/IP protocol.)
2. From the Start menu, select Settings > Network And Dial-up Connections.
3. Right click on the connection you want to configure and choose Properties. On the General tab under Components Used By This Connection, select Internet Protocol (TCP/IP) and click the Properties button.
4. Configure the connection's TCP/IP properties to use IPsec.



5. On the TCP/IP Properties page, click the Advanced button at the bottom of the page.
6. Click the Advanced button to configure IPsec.



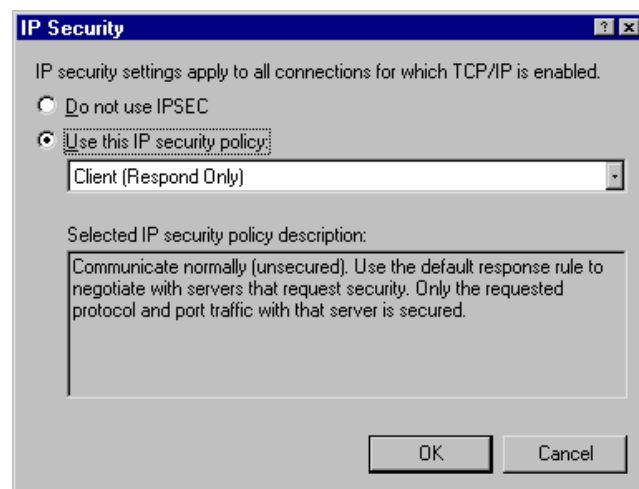
7. Now click the Options tab. Under Optional Settings, select IP Security and click the Properties button.



8. To enable IPsec secured communications, select the Use This IP Security Policy option and select an IPsec policy from the drop-down list.

This will allow you to enable IPsec secured communications.

By default, you can select one of three predefined IPsec policies: Client (Respond Only), Server (Request Security), or Secure Server (Require Security).



Client (Respond Only) – If you choose the Client policy, IPSec will not secure communications unless the destination server requests or requires it. This setting would be appropriate if the client is on an intranet, where most communications don't need to be secured.

Server (Request Security) – If you choose the Server policy, the computer will attempt to negotiate a secure communication when another computer initiates an exchange. However, if the computer on the other end is not able to do so—for example, if it's a Windows NT 4.0 machine, which does not support IPSec—the computer will accept unsecured communications.

Secure Server (Require Security) – If you choose the Secure Server policy, the computer will accept and send only secured communications. If the computer on the other end is not IPSec-enabled, however, all traffic will be rejected. This setting should be used if the computer transmits data that is very sensitive or confidential.

Creating, Modifying, and Managing IPSec Policies

Microsoft provides an IP Security Policy MMC snap-in for managing policies. Although the default policies will meet the needs of many organizations, you can modify them or create custom policies to fit your needs.

IPSec policies can be applied either locally or via Active Directory (in a Windows 2000 domain) using group policies. We will be focusing on management of local policies.

You can create a custom MMC with the IPSec snap-in (see the tip below on creating an IPSec MMC), or you can access the policies via Start > Control Panel > Administrative Tools > Local Security Settings.

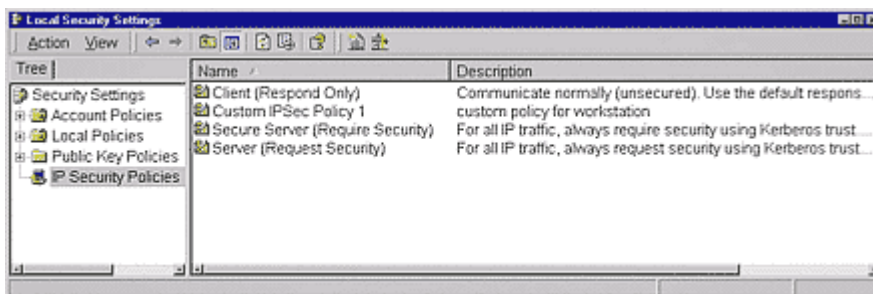
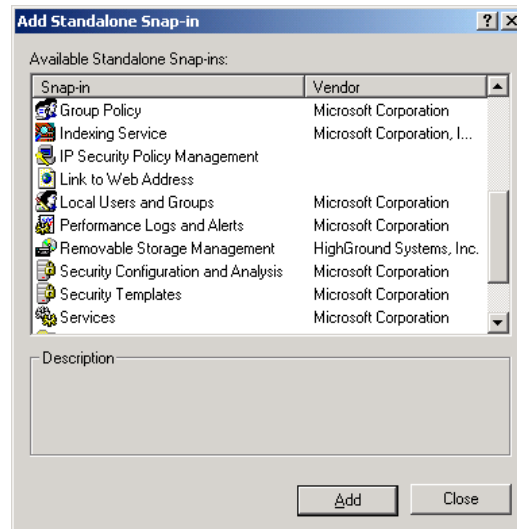


Figure 36: Local Security Settings

The three predefined policies appear in the right details pane by default. Any custom policies you create will appear there as well. Note that the Local Security Settings MMC shown in Figure 36 shows the three default IPSec policies and one custom policy.

Creating a Custom IPsec MMC in Windows 2000 Professional

1. From the Start Menu, select Run and type “mmc” in the Run box.
2. In the new, empty MMC console, open the Console menu at the top left and select Add/Remove Snap-In.
3. In the Standalone tab, click the Add button. This opens the Add Standalone Snap-In dialog box.
4. In the Add Standalone Snap-in window, scroll through the list of available standalone snap-ins and select IP Security Policy Management. Click the Add button. This will display the Select Computer dialog box.
5. Because you are creating an MMC to manage local IPsec policies, you should select the Local Computer option in the Select Computer dialog box. Click Finish.
6. Click Close in the Add Standalone Snap-In box and click OK. The IP Security Policies node will now appear in the left pane of the snap-in.



You can save this console by selecting Save As from the Console menu. By default it will be saved in the Administrative Tools folder.

To change the console mode, select Console > Options. Choose Author mode if you want users of the MMC to have full access to all its functionality, including the ability to add or remove snap-ins and create new windows. Select User mode - full access if you want to allow users to use all commands and have full access to the console tree but prevent them from adding or removing snap-ins. Select User mode—limited access (single window or multiple window) if you want users to be able to access only the areas of the console tree that were visible when the console was saved.

IPsec policies are made up of filters and filter actions, and you can select the protocol(s) to which they will be applied.

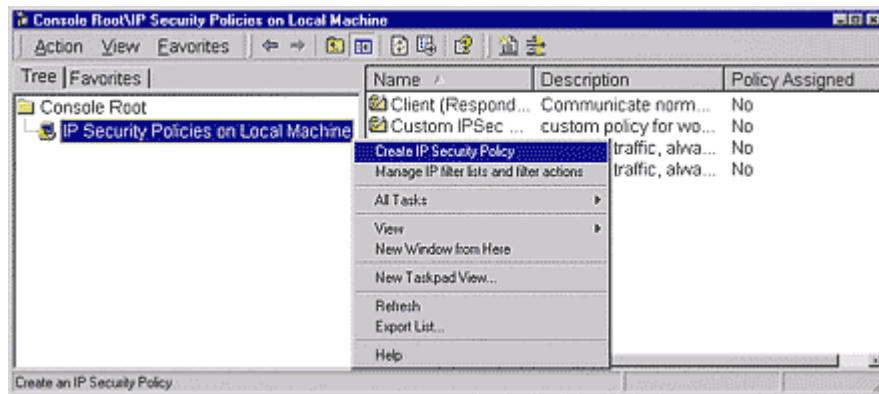
Creating a New IPsec Policy

You can create your own custom IPsec policies using the IPsec MMC.

1. Right click on IP Security Policies On Local Machine in the left console pane. Choose Create IP Security Policy.

This will invoke the IP Security

Policy Wizard, which will walk you through the steps for creating a custom policy.

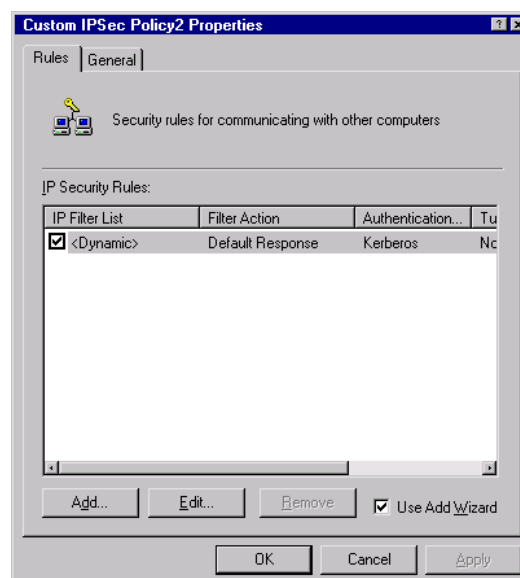


2. The wizard will first ask you to provide a name and description for the new policy.
3. On the next screen, the wizard will ask you to specify how the policy should respond to requests for secure communications. The response that is active by default specifies that the computer must respond to requests for secure communication in order to establish IPSec-protected communications. This rule will be used when no other rule applies.
4. The third screen will ask you to set an initial authentication method for the rule. By default, the Windows 2000 Kerberos v5 protocol is used. You can instead choose to use a certificate (in which case you must specify a certificate authority to issue the certificate), or you can select to use a preshared secret key, which is merely a string of characters that must be shared between the two communicating computers.
5. Finally, you will be asked to click Finish to create your new policy.

Creating and Editing Security Rules for the New Policy

After creating the new policy, you can edit its properties. (You can edit the properties of a policy at any time by double clicking on it in the right console pane or right-clicking and selecting Properties.)

1. In the Properties dialog box, select the Rules tab and click Add or Edit as appropriate.
2. You can choose to use the Add Wizard by selecting the check box in the lower right corner. The wizard will walk you through the steps for creating a security policy that specifies how and when security will be used, based on criteria such as the source computer, the destination computer, or the type of IP traffic.



Using the Security Rule Wizard

When the data packets for a communication match the specified criteria, one or more security actions will be performed. These actions are configured as you go through the steps of the Security Rule Wizard, which are as follows:

1. *Specify whether this rule will cause an IPsec tunnel to be created.* IPsec tunneling is used to create a virtual private network link, usually in situations where the other computer does not support L2TP tunneling. If you specify that a tunnel will be created, you must provide the IP address of the computer that will serve as the endpoint of the tunnel. (By default, a new rule does not specify a tunnel.)
2. *Select the type of network connection to which the rule should be applied.* You can choose from All Network Connections (the default), Local Area Network (LAN) Connections, or Remote Access Connections.
3. *Specify an initial authentication method for the rule.* Select a method from the three options discussed above in Creating a New IPsec Policy (Windows 2000 Kerberos, certificate, or a preshared key).
4. *Identify the type of IP traffic to which the rule will apply.* The IP Filter List configuration sheet presents the following default options: All ICMP Traffic and All IP Traffic. To add additional filters, select the Add button on the IP Filter List screen. This will invoke the Filter Wizard. You can configure these filters very specifically. You can specify that the rule apply to a particular IP address or subnet, a specific DNS name, your own IP address, or any IP address. You can also specify that the rule apply to any of the following protocol types: EGP, HMP, ICMP, RAW, RDP, RVD, TCP, UDP, XNS-IDP. Or you can specify that it will apply to any protocol. If you select a protocol that uses a port (such as TCP or UDP), a port number will also be specified.
5. Select or create a filter action for the rule. Default actions you can select include
 - Permit – This allows unsecured packets to pass through.
 - Request Security - Optional – This negotiates security. It will accept unsecured communications but always responds using IPsec. It will also allow unsecured communications if the other computer is not IPsec-aware.
 - Require Security – This will not allow unsecured communications with non-IPsec-aware computers

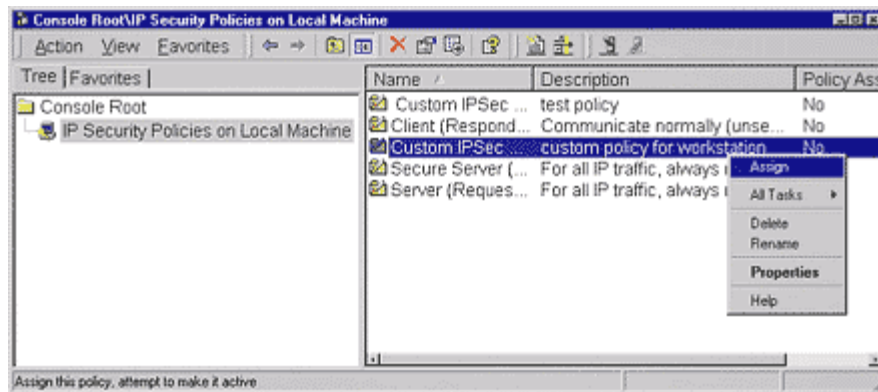
If none of the predefined filter actions fits your needs, you can create a custom filter action using—you guessed it—the Filter Action Wizard. In creating the new filter action, you can specify whether you want the computer to be able to communicate with computers that do not support IPsec. On the IP Traffic Security sheet, you can also choose the IPsec protocol that will be used by this filter action (ESP or AH). By choosing the Custom option, you can even specify the integrity and encryption algorithms to be used by AH and ESP, and how often a new key will be generated.

Note: AH and ESP can be used together. After you have added a rule with the Security Rule Wizard, you can edit the properties of the filter action to add a second security protocol.

Assigning the New Policy

Before your computer can use a policy to establish IPSec secured communications, you must assign the new policy. By default, no policies are assigned.

Right click on the policy in the right details pane of the MMC and select Assign. The word “Yes” will now appear in the column labeled Policy Assigned. (To stop using a policy, right click on it and select Unassign.)



Summary

IPSec is a useful feature included in the Windows 2000 Professional and Server operating systems that allows you to sign and encrypt data that you send across a network or the Internet. For computers running Windows 2000 Professional, you can

- use IPSec security protocols, AH, and ESP to provide authentication, integrity, and/or confidentiality of the network communications in which your computer participates
- configure your computer to use IPSec using a variety of wizards that allow you great flexibility and control over IPSec policies

Proxy Filtering

Filtering is based on specific application data.

Done for many common protocols and services
(Telnet, FTP, SMTP, HTTP, etc.)

Filtering decisions based on a variety of triggers

- Source/destination addresses
- Contents of the connection (content filtering)

2.9.3 Proxy Filtering

An application proxy is an application program that runs on a firewall system between two networks. The host on which the proxy runs does not need to be acting as a router. When a client program establishes a connection through a proxy to a destination service, it first establishes a connection directly to the proxy server program. The client then negotiates with the proxy server to have the proxy establish a connection on behalf of the client between the proxy and the destination service. If this is successful, there are then two connections in place: one between the client and the proxy server and another between the proxy server and the destination service. Once established, the proxy then receives and forwards traffic bi-directionally between the client and service. The proxy makes all connection-establishment and packet-forwarding decisions. Any routing functions that may be active on the host system are irrelevant to the proxy.

As with packet filtering, application proxies are available on both special purpose proxy machines and general purpose computers. Generally speaking, application proxies are slower than packet filtering routers, as there is a great deal of processing and storage overhead associated with creating, maintaining, and managing the two connections for every connection made through the proxy. However, in some ways application proxies are inherently more secure than packet filtering routers. They depend on a lot of higher layer intelligence, and expend a great deal of resources in offering that security.

The application proxy is configured for a specific service: inspecting all the traffic that it handles as it passes it from one network to another. There are a number of services for which proxying is common—and Internet Web browsing traffic is the most common of these. We'll use it in our examples, but the rest of the proxy filters perform very similar functions for their specific services.



Proxy Filtering Examples— SquidGuard & Dan's Guardian

Squid—common Linux Web proxy/cache

Can be configured to also do filtering

Plugins such as SquidGuard and Dan's Guardian

Demo: Squid and SquidGuard

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Module 2: Firewalls and Network Access Controls—Slide 24

SquidGuard

Squid is the most popular and most common open-source Web proxy.²⁴ Squid is designed to run on Linux/UNIX systems. As with all proxies, it is set up to receive http requests from the clients for which it is proxying. After consulting its rules to ensure that (a) the client is making a valid request and (b) the request itself does not violate any of the rules we will discuss later, the proxy makes a request for the Web page being requested by the client. It receives the content on the client's behalf, inspects the content (again to make sure that the content of the response is valid and does not violate any rules), and then sends it on to the client. For performance reasons, Squid can be configured to cache Web pages it gets on behalf of its client. Subsequently, if there are additional requests for the same URL, Squid can simply send the cached content. This can cut down on Web requests and bandwidth consumption.

We're able to "plug in" technologies for our Squid proxy, which will allow us to do more thorough content filtering on our http traffic. SquidGuard and DansGuardian are the two technologies (open-source, of course) on which we will focus.

SquidGuard works with Squid to block access to sites by domain, IP address, or even keywords. It is very flexible, allowing you to block and allow access according to the time of day and to define groups within your organization that have different access privileges.

²⁴ <http://www.squid-cache.org>

This all works because Squid allows you to define a redirector program that gets to examine each requested Web page before Squid goes and gets it. If the redirector determines a request violates an ACL, Squid will serve up the redirected page.

DansGuardian is a Web content filtering proxy for Linux, FreeBSD, OpenBSD, NetBSD, Mac OS X, and Solaris that uses Squid to do all the fetching. It filters using multiple methods. These methods include content phrase filtering, POST limiting filtering, URL and domain filtering, Platform for Internet Content Sharing (PICS) filtering, MIME filtering, and file extension filtering. The content phrase filtering will check for pages that contain profanities and phrases often associated with pornography and other undesirable content. The POST limiting filtering allows you to block or limit Web downloads or uploads. The URL and domain filtering is able to handle huge lists and is significantly faster than SquidGuard. The filtering has configurable domain, user, and source IP exception lists. SSL Tunneling is supported.

The configurable logging feature produces a log in an easy-to-read format which provides the option of only logging the text-based pages, significantly reducing redundant information such as every image on a page. All parts of DansGuardian are configurable, giving total control over what is filtered to the end user administrator and not some third-party company.

Configuring Squid to Do Content Filtering

We'll use Webmin again to manage the access control rules for our Web content filter, which will be Squid in this case. Here's an overview of making one access control rule in Squid.

We need to get the Squid proxy server running, along with Webmin. We will assume that squid is running on this host.

1. Open a Webmin management window and browse to the Servers page.
2. Click on the icon for Squid Proxy Server (see Figure 37).



Figure 37: Squid Proxy Server Icons

3. We'll start by changing the listening port for Squid from the default, TCP Port 3128, to another standard proxy port, TCP Port 8080. To do this, we click on the Ports and Networking icon from the Squid Proxy Server page (see Figure 37).

- Next, check the radio button for “Listed below” and type 8080 in the dialog box under Port. This causes Squid to listen on port 8080. Click the Save button to save the changes. Clicking save will bring back the Squid main page.
- Next we will create an access control list to block some bad Web sites. To do this, click on the Access Control icon (see Figure 37).

Ports and Networking

Ports and Networking Options

Proxy addresses and ports: ☐ Default (usually 3128) ☒ Listed below..

Port	Hostname/IP address
8080	<input type="radio"/> All <input type="text"/>
<input type="text"/>	<input type="radio"/> All <input type="text"/>

ICP port: ☐ Default ☐

Outgoing UDP address: ☐ Any

Multicast groups:

Outgoing TCP address: ☐ Any

Incoming UDP address: ☐ Any

TCP receive buffer: ☐ OS default

Figure 38: Ports and Networking in Squid Proxy Server

- From the drop-down box on the lower left of the Access Control page, select “Web Server Address.” This will allow a rule to be created which will block a specific Web server by its address. Click the Create New ACL button to edit the ACL rules:

- On the Edit ACL page, enter a name for the ACL rule (BadWebSite in this example). Do not use spaces! Enter the IP address of the Web site you want to block (128.2.243.156 in this example) and the Netmask (/32 in this case—to block only that specific IP address). Leave the Failure URL blank to get the Squid default denial when the ACL is met and the site is blocked. Click Save to save the rule and return to the Access Control main page.

Edit ACL

Web Server Address ACL

ACL Name:

IP Address: Netmask:

Failure URL:

Figure 39: Edit ACL in Squid Proxy Server

8. Now that the ACL is built, we need to apply it. To do that, we'll add a proxy restriction. Click the "Add Proxy Restriction" link under the Proxy Restriction heading on the right of the Access Control main page.
9. Highlight the name of the ACL you created, select the Deny radio button, and click Save to save the proxy restriction and return to the Access Control main page.

Figure 40: Edit Proxy Restriction in Squid Proxy Server

Squid's default behavior upon installation is to block all outbound traffic, as evidenced by the "Deny All" proxy restriction. You will need to edit this by clicking the Deny link under the Proxy Restriction heading and changing the Allow radio button, ensuring that "all" is highlighted under the Match ACLs text box. Click Save to change this rule.

Figure 41: Changing Defaults to Allow Outbound Traffic in Squid Proxy Server

10. You'll also need to ensure that the proxy restrictions are in the right order. Like all packet filters, Squid compares requests to its proxy restriction list in order and makes a filtering decision based on the first match it encounters. Therefore, if your "Allow All"

rule is above your filtering rule, all requests will be granted because the filtering rules will never be reached. To move the Allow All rule down to the bottom of the list, click the down arrow to the far right under Move to move the rule to the bottom of the list. This will ensure that all deny rules are tested before the Allow All rule is encountered.

Proxy restrictions		
Action	ACLs	Move
Allow	manager localhost	↓
Deny	manager	↓ ↑
Deny	!Safe_ports	↓ ↑
Deny	CONNECT !SSL_ports	↓ ↑
Allow	localhost	↓ ↑
Deny	BadWebSite	↓ ↑
Allow	all	↑

[Add proxy restriction](#)

Figure 42: Ordering Proxy Restrictions in Squid Proxy Server

- Now we should test the proxy rule. We must point a Web browser at the Squid system, to port 8080, and try to browse to the IP address we blocked with our rule. If Squid is configured correctly, we should see the Squid-generated Web page shown in Figure 43.

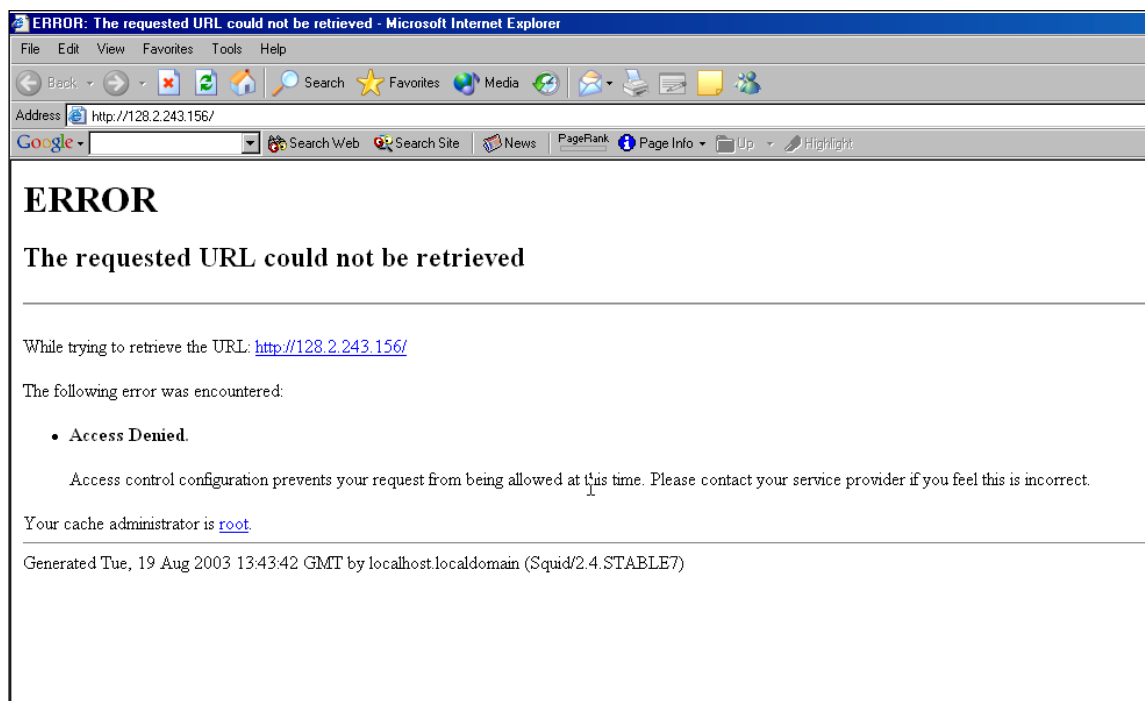


Figure 43: What a Browser Displays for a Blocked IP Address When Squid Proxy Server Is Configured Correctly

Firewall and Network Access Controls: Pros & Cons

Pros

- Multiple point for access control
- Most are 'easy' to configure
- New technologies allow for 'Intrusion Prevention'
- Granularity can be achieved at network and host levels

Cons

- False sense of security
- Tunneling and encryption difficult for firewalls
- Single point of failure (?)

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Module 2: Firewalls and Network Access Controls–Slide 25

2.10 Pros and Cons of Firewall and Network Access Controls

2.10.1 Pros

There are a number of good things to be gained by implementing firewalls and network access controls, including the following:

- *Lots of places to do access control* – Implementing these types of systems gives administrators the ability to manage what's happening on the network in many different places at many different layers. Traffic can be limited by a firewall; access can be limited by a proxy filter; access can be managed by application configuration files; access can be controlled through wrappers. This offers a great deal of flexibility to administrators who need to manage access and access controls.
- *Ease of use* – Most of the technologies and configurations mentioned up to this point are not terribly difficult to implement and manage. Some may be relatively time consuming at first, but the continued maintenance and administration gets significantly easier after initial implementation.
- *Intrusion Prevention capabilities* – Many of these technologies—especially the application layer filters—have the ability to manage access and prevent malicious packets from ever getting onto the network or to the host, thus avoiding or preventing intrusions. These are powerful tools to increase security within the enterprise.
- *Multi-layer functionality* – These technologies work at nearly every layer of the normal defense in depth approach, thereby offering administrators the capability to manage network access at all those levels.

2.10.2 Cons

However, the added security which comes from these technologies is not without a price. Some potential drawbacks include the following:

- *False sense of security* – Many organizations simply say “Security? Oh, we have a firewall, so we’re good!” The presence of network filters and access controls does not necessarily make the enterprise completely secure. In fact, it only addresses a part of the enterprise’s security needs. It is one of the most important pieces of the defensive posture of an organization—possibly the most important—but it is not the only one. Other technologies and processes must be put in place to ensure that the network is as secure as it needs to be.
- *Encryption issues* – Firewalls can only make decisions based on what they know and understand. Encryption creates problems for firewalls. Encrypted data which passes by the firewall cannot be completely inspected, and thus must either always be forwarded or always be dropped. There is little room for flexibility without serious investment in cryptographic infrastructure.
- *Single point of failure (SPOF)* – Many enterprises have only one external Internet-facing firewall. In the event this system becomes inoperable, the connection to the Internet (or whatever the remote network is to which the firewall connects the protected network) will be unavailable. This is not necessarily a security problem; it is an availability problem. Problems like this can be avoided by sound design and network engineering, but are often overlooked because of resource constraints. At any rate, creating a SPOF (with a firewall or any other network device) is a bad practice for any organization that relies on availability as a part of their mission accomplishment.

Summary

Many places for network access control and filtering

- Firewalls for network packet filtering
- Service and application ACLs
- “Wrappers” like TCP Wrappers or IPsec
- Proxy Filters

All should “let in the good, keep out the bad!”

Administrator’s job: determine what is “good” and what is “bad” and implement technologies to support

2.11 Summary



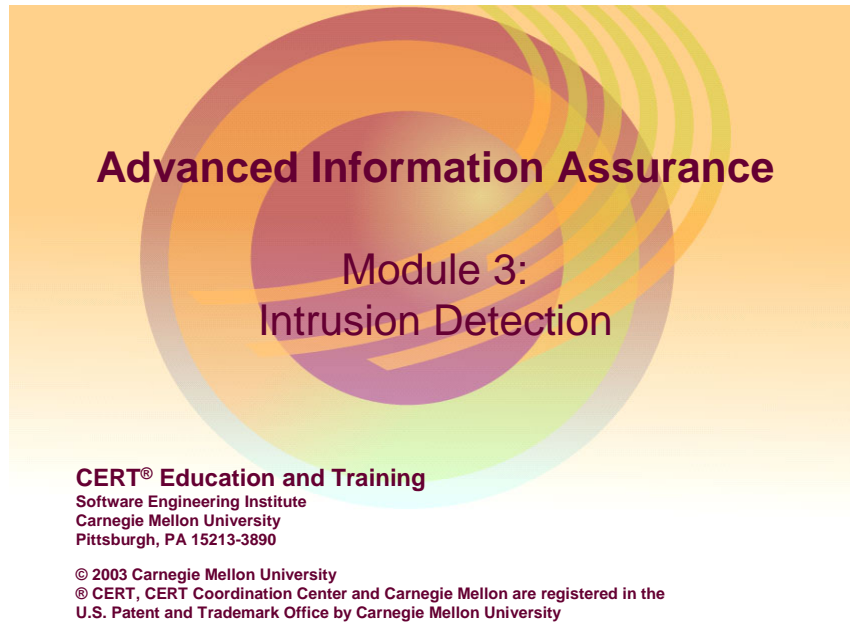
Review Questions

1. What rules make up ingress and egress filtering?
2. What characteristics of a TCP packet can a stateless packet filter use to make filtering decisions?
3. What network services fit best in a DMZ?
4. What are the CHAINS which are part of the IPTables firewall suite?
5. What IPTables rule will log all packets?

2.12 Review Questions

1. What rules make up ingress and egress filtering?
2. What characteristics of a TCP packet can a stateless packet filter use to make filtering decisions?
3. What network services fit best in a DMZ?
4. What are the CHAINS which are part of the IPTables firewall suite?
5. What IPTables rule will log all packets?

3 Intrusion Detection





Instructional Objectives

Identify locations in an enterprise network where an IDS should be placed.

Identify what IDS rules/signatures meet the needs of the network.

Identify the appropriate type of IDS for networks and hosts.

Configure a network-based IDS.

Configure a host-based IDS.

3.1 Instructional Objectives

Students will be able to do all of the above upon completion of this module.

Overview

Understanding IDS and Snort

Placing an IDS on a network

Configuring a network-based IDS

Optimizing IDS signature rulesets

Writing new rules

Configuring host-based IDS

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3.2 Overview

This module will cover the topics outlined above as it presents the many tasks involved in using intrusion detection systems (IDSs) on a network:

- deciding what type of IDS to use
- deciding where to place IDS on a network
- learning how to set up and use the network-based IDS Snort and how to set up and configure some of the various add-ons and plug-ins for Snort
- optimizing the IDS to reduce the number of false positive alerts
- customizing the rules/signatures used with Snort
- learning how to set up and use the host-based IDS Tripwire
- learning how to set up and use the LANguard System Integrity Monitor (SIM) file checker

IDS Quick Review: What Is an IDS?

A device on a network that monitors traffic and/or host activity looking for the following:

- Malicious traffic such as attempts to circumvent identification & authorization or other access controls
- Reconnaissance traffic, such as port scans
- Unusual traffic: type, level, source, etc.
- Activity on host systems that is outside of known or expected parameters

Device then logs and reports activity in prescribed manner

3.3 Review of Intrusion Detection Systems

3.3.1 What Is an Intrusion Detection System?

An intrusion detection system is essentially a network burglar alarm, similar to the alarms placed on doors and windows of a building. If a potential intruder is testing doors and windows, or trying to break in some other way, the burglar alarm will generate an alert. The alert is generally user-configurable: it may simply set off a local siren, it may turn on floodlights, it may call the police; or it may do some combination of the above. The IDS can be configured to log traffic, to generate an alert or console message, or to page the system administrator. The action that the IDS takes must be configured according to site policy and regulations.

An IDS can also catalog a series of alerts and produce a trend analysis report. These types of reports are valuable because they can alert an administrator to patterns of attacks. Trend analyses can be configured to look for what have been termed “low and slow scans.” A low and slow scan is a long series of infrequent scans done in such a way as to hopefully not alert an IDS that an intruder is scanning a network. Trend analyses can also show increasing or decreasing behavior, where the behavior can be the quantity of attacks, the frequency of attacks, and/or the severity of attacks. This information can then be used to make decisions about where to allocate defense resources to achieve the optimum results for the least cost.

3.3.2 Intrusion Analysis Architecture

The following is an excerpt from *Enabling Automated Detection of Security Events* [Pickel 00] that describes the architecture of distributed intrusion detection systems.

In order to implement any scalable intrusion analysis system, there are four main components that must be considered. These components allow the system to be robust and reliable when deployed across multiple network segments.

Sensor

A sensor detects security-related events and reports them to a central collector. By their very nature, intrusion detection systems are superior sensors because these two features (detection and reporting) were core design decisions. Other than intrusion detection systems, other devices that make good sensors would include any such device with high visibility on the network. Specifically, routers and firewalls can make effective sensors.

Collector

A collector is a server that is responsible for accepting and aggregating alerts from the various sensors deployed throughout each network segment. The collector will parse the alert for completeness, and then write the data to a data store.

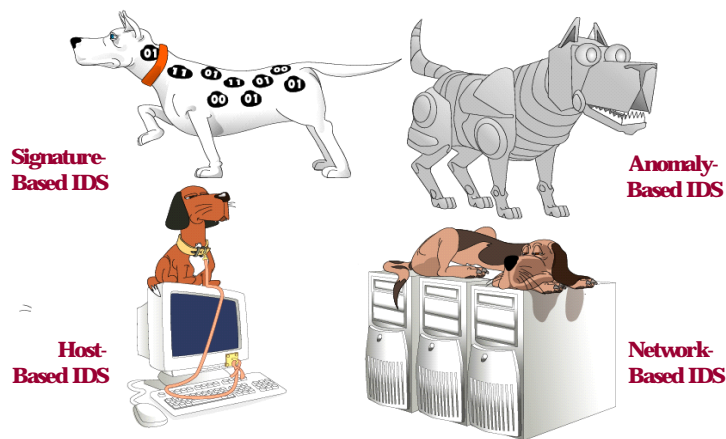
Data Store

The data store refers to any permanent storage (e.g., a database) in which alerts generated by the sensors are stored for analysis. Since there will likely be a tremendous amount of data that must be stored, the data store should be given an overabundance of resources to prevent performance issues.

Analysis Engine

The analysis engine is the user interface to the alerts stored in the database. Through the use of the engine, the alerts can be examined to determine attack trends as well as the efficacy of access control and packet filtering systems.

IDS Quick Review: Types of IDS



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3.3.3 Types of IDS: Signature and Anomaly

There are two basic analysis types for intrusion detection systems: signature-based and anomaly-based. Both of these types can be deployed on either a single host (HIDS) or a network (NIDS). Theoretically, four different combinations of IDS are possible, although there is probably no anomaly-based HIDS in existence as the information provided from such a system is either not important or is dealt with via ACLs and/or a host-based firewall.

A signature-based HIDS takes hash values of all of the important system files on the host. Ideally, the initial hash values should be recorded when the system files have most recently been installed from a trusted source. The HIDS is then configured to recheck the hash values at regular intervals in order to compare them to the initial hashes and determine if there have been any changes made to any of those files. In the event of an alert, the administrator must determine whether or not the changes made to a file were supposed to have been made. If so, the initial hash signature for the changed files must be updated in the HIDS configuration. In this module, we will look at two signature-based HIDS: Tripwire for UNIX and LANGuard SIM (System Integrity Monitor).

Whereas HIDS verify the integrity of important files on a single system over time, NIDS are designed to detect (and occasionally block) suspicious or unusual traffic flow on a network.

A signature-based NIDS is like the security screener at the airport. He has a list of people that are suspected terrorists. He has seen their photos and knows what they look like. When he recognizes one of these people, he either stops that person from entering the terminal or alerts other authorities that the suspicious person has entered the terminal. Similarly, when a new computer attack/intrusion is detected, the packets that make up that attack are identified by

the pattern of the packets transmitted. This pattern is called a signature. The signature-based NIDS is configured with a list of these attack/intrusion signatures and every time a new attack signature is identified, the NIDS configuration should be updated with the new signature. Then, when a transmission of packets tries to enter the system, the NIDS compares the signature of the packets to the list of suspicious signatures. When a match is identified, the NIDS either disallows that transmission to enter the system or creates an alert that the suspicious transmission has entered the system.

A signature-based NIDS keeps a list of suspicious signatures to block or create an alert. In this module, we will look at Snort, one of the most popular and useful signature-based NIDS available as freeware.

An anomaly-based NIDS creates a statistical baseline representation of normal and acceptable network traffic over a representative period of time and then compares all future traffic to that baseline. For example, the system is run for a period of one month, during which time the network administrator is taking special care to ensure that the network traffic is actually normal and acceptable. The NIDS is then configured to know how much variation from that statistical baseline is considered acceptable. Then, when the NIDS detects network traffic that is outside of the acceptable limits of traffic type or volume, it creates an alert. This type of NIDS is still experimental and problematic. Any time that there is a change on the network, such as adding a new device or service, the network traffic will no longer be consistent with the statistical baseline. The baseline will need to be recreated each time a change is made. Aside from the pain of ensuring a good initial statistical baseline, the time it would take to recreate it with each new change makes anomaly-based NIDS not viable for a production environment. Additionally, the volume of network traffic can change as an organization grows and the type of traffic can change when existing devices and services are used in new ways.

IDS: Snort

Signature based

Network based

Most widely used open source IDS

<http://www.snort.org/>

3.4 Snort

Snort²⁵ is a small, lightweight open source IDS written by Marty Roesch which has become the most widely used IDS. It is capable of performing real-time traffic analysis and packet logging on IP networks.

3.4.1 Snort Features

Snort features include the following:

- engine capable of detecting more than 1300 different types of attacks
- ability to alert based on pattern matching for threats including buffer overflows, stealth port scans, CGI scans, SMB probes, NetBIOS queries, DDoS attacks, Trojan horse attacks, and certain types of viruses and worms
- real-time alerting/logging options including using syslog, Server Message Block (SMB) “WinPopUp” messages, or a flat file
- ability to record packets in human-readable, binary, XML, and other formats
- network-based IDS that uses the libpcap²⁶ packet capture library
- configurable using command line switches and optional Berkeley Packet Filter commands

²⁵ <http://www.Snort.org>

²⁶ http://freshmeat.net/projects/libpcap/?topic_id=809

- detection engine is programmed using a simple language that describes per packet tests and actions. Ease of use simplifies and expedites the development of new exploit detection rules.
- able to compile and run on a multitude of hardware and software platforms including most versions of Linux and UNIX, Windows, and Mac OS X (Snort's native OS is Linux)



Snort Architecture

Packet Capture and Decoding Engine

Preprocessor Handling Engine

- http_decode
- stream4
- frag2
- portscan and portscan2

Detection and Rule Parsing Engine

Alerting/Logging Engine

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3.4.2 Snort Sensor Architecture

The most important part of any intrusion analysis system is the sensor used to detect security related events. The better the sensor, the more events can be harvested and the better the quality of analysis and trending. The Snort sensor's internal architecture can be divided into the four major modules described in the following paragraphs.²⁷

Packet Capturing and Decoding Engine

This is the initial entry point into the Snort sensor. The behavior of the packet capturing and decoding engine (built around libpcap) is similar to a surrogate TCP/IP stack and is responsible for detecting packets on the physical transmission medium. Once a packet is detected, it is captured and propagated up the stack to be decoded. As the packet traverses the different layers of the stack, decoding routines set pointers into the raw packet data for later use by the detection engine. These pointers serve as bookmarks in the packet so that the Detection engine can efficiently retrieve any information that is present in an IP packet (IP address, TCP options, etc.). Once the data packets have been decoded into the different protocols, the processing follows three phases:

1. preprocessors
2. detect engines and plug-ins
3. output plug-ins

²⁷ <http://packetstormsecurity.nl/papers/IDS/lisapaper.txt>

Preprocessor Handling Engine

Before the packets are sent to the detection engine, they are first sent to the preprocessors. The main idea behind the introduction of preprocessors was to provide a framework to allow for alerting, dropping, and modification of the packets before they reached Snort's main detection engine. There are many preprocessors available for Snort, and you can even write your own. We will only mention five here, and leave the rest to a book or paper with more information on the topic. One such book is *Snort 2.0 Intrusion Detection* [Caswell 03].

- **http_decode** – This preprocessor normalizes uniform resource identifier (URI) links that use hexadecimal notation. For example, let's say a user sends a request to the Web server with this URI:

```
http://10.0.1.4/%2E%2E%2F%2E%2E%2F%2E%2E%2F%77%69%6E%6E%74%2F%73%79%73%74%65%6D%33%32%2F%63%6D%64%2E%65%78%65%2F%63%2B%64%69%72%2B%43%3A%5C
```

If Snort did not decode this hexadecimal URI notation into the actual URI before running it against the rule set, it would not see this URI as a problem. As it turns out, this is the ASCII version of the decoded URI:

```
http://10.0.1.4/../../../../winnt/system32/cmd.exe /c+dir+C:\
```

This URI is a typical directory traversal attack against an IIS server. Because of the http_decode preprocessor, Snort is able to see what the malicious user really has in mind, and can alert the administrator.

- **stream4** – This is currently one of the largest components of Snort. It provides stateful packet inspection capabilities. One of the typical port scanning mechanisms used by hackers is to do a SYN or FIN scan. Essentially these are scans where the hacker is trying to send packets out of order to confuse the victim machine's TCP/IP stack and elicit information from the victim machine's response. If Snort operated purely in a stateless mode, it would have no way to tell whether the packets anyone sent were in a legal sequence. Stream4 gives Snort the ability to thwart these out of state order connections, and to alert the administrator.
- **frag2** – This preprocessor reassembles all pieces of fragmented packets before Snort attempts to apply the ruleset. Typically, fragmentation is used to disguise malicious traffic from the IP filters that are used in routers and firewalls. A malicious user could fragment the packets of attack traffic, hoping that the fragments pass by the filters and IDS without triggering any action. This occurs in systems that are unable to reassemble fragments before applying filtering or alerting rules to them. The frag2 preprocessor was designed to ensure that packet fragmentation does not allow attacks to bypass Snort. The maximum packet size on modern networks is 512-bytes; packets smaller than this do not

need to be fragmented. If packets smaller than the 512-bytes are found to be fragmented, it could indicate an attempt to subvert an intrusion detection system.

- **portscan and portscan2** – Preprocessors in the portscan family give Snort the ability to track portscans, which is one of the most important features of an IDS. These plug-ins essentially track the state of connections similar to the stream4 preprocessor. Portscan is the predecessor to portscan2, but it is stable and works more quickly than portscan2. Tuning these preprocessors can be challenging depending on your network but is well worth the time. You should try both preprocessors and see which one works better for your network.

Rules Parsing and Detection Engine

When Snort is initialized, the rules parsing portion of this module is responsible for reading in the rules file, and performing translation (e.g., by expanding variables and incorporating preprocessor directives) to convert the rule from a flat-text command into a form usable by the detection engine. The detection engine receives packets once they have been completely decoded and is responsible for examining the packet to determine if a security alert must be raised. The detection engine checks only those rules which have been set by the rules parser at run-time. The first rule that matches a decoded packet in the detection engine triggers the action specified in the rule definition and returns.

Alerting/Logging Engine

When the detection engine determines that a particular packet (or stream of packets) matches a rule, the alerting/logging engine is used to signal the event. The particular method used by the alerting/logging engine subsystem is selected at run-time using command line switches. If logging is selected as the primary alert method, there are two options. Packets can be logged in human-readable format to an IP-based directory structure (for manual log analysis) or they can be recorded in binary tcpdump format (for automated analysis).



Snort Advantages

Can be installed with a minimal footprint on cheap hardware and software (Pentium 1/Linux)

Can monitor multiple machines from one physical and logical location

Console can generate an alert if a monitored machine/network has ceased to send information

Easily configured/written rules language that allows anyone to write new rules/signatures

Snort is fast—on par with commercial IDS

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3.4.3 Snort Advantages

Snort is an open source project, available for anyone to use for free. Compare this with the price of commercial IDS and you will quickly see why this is such a huge advantage.

Most networks with limited personnel resources can benefit greatly from using Snort. One person can monitor a number of machines effectively, reducing personnel requirements. The management console often can be configured to send an alert if communication is lost with a monitored machine. Having all the data from multiple machines in one location can allow the operator to spot trends and patterns—and anomalies—in traffic.

As you will see from deployment scenarios later in this module, Snort can be placed strategically to enable centralized inspection and analysis of critical network traffic. Additionally, information can be obtained about trends in the kind of data traffic that is traversing the IDS. This can lend itself to optimization and filtering implementations. It can also be used to evaluate and fine tune access control rules on firewalls and routers.

Snort is fast—many organizations who spend thousands of dollars on commercial IDS find that they fall back to their Snort sensors due to their stability, reliability, and speed. Snort is flexible in configuration and can be modified to suit the purposes of an organization without paying licensing fees.

Snort also uses its own rules language, allowing users to customize its detection signatures according to the requirements of the network.

Figure 44 shows an example of a Snort rule file.

```

# (C) Copyright 2001,2002, Martin Roesch, Brian Caswell, et al.
# All rights reserved.
# $Id: pop3.rules,v 1.4 2002/08/18 20:28:43 cazz Exp $
#-----
# POP3 RULES
#-----

alert tcp $EXTERNAL_NET any -> $HOME_NET 110 (msg:"POP3 USER overflow attempt";
flow:to_server,established; dsize:>500; content:"USER "; nocase; reference:cve,CVE-
1999-0494; reference:nessus,10311; classtype:attempted-admin; sid:1866; rev:2;)

alert tcp $EXTERNAL_NET any -> $HOME_NET 110 (msg:"POP3 PASS overflow attempt";
flow:to_server,established; dsize:>500; content:"PASS "; nocase; reference:cve,CAN-
1999-1511; reference:nessus,10325; classtype:attempted-admin; sid:1634; rev:5;)

alert tcp $EXTERNAL_NET any -> $HOME_NET 110 (msg:"POP3 APOP overflow attempt";
flow:to_server,established; dsize:>500; content:"APOP "; nocase; reference:cve,CAN-
2000-0841; reference:nessus,10559; classtype:attempted-admin; sid:1635; rev:4;)

alert tcp $EXTERNAL_NET any -> $HOME_NET 110 (msg:"POP3 EXPLOIT x86 bsd overflow";
flow:to_server,established; content:"|5e0 e31c 0b03 b8d7 e0e8 9fa 89f9|";
classtype:attempted-admin; sid:286; rev:4;)

alert tcp $EXTERNAL_NET any -> $HOME_NET 110 (msg:"POP3 EXPLOIT x86 bsd overflow";
flow:to_server,established; content:"|685d 5eff d5ff d4ff f58b f590 6631|";
classtype:attempted-admin; sid:287; rev:4;)

alert tcp $EXTERNAL_NET any -> $HOME_NET 110 (msg:"POP3 EXPLOIT x86 linux overflow";
flow:to_server,established; content:"|d840 cd80 e8d9 ffff ff|/bin/sh";
classtype:attempted-admin; sid:288; rev:4;)

alert tcp $EXTERNAL_NET any -> $HOME_NET 110 (msg:"POP3 EXPLOIT x86 sco overflow";
flow:to_server,established; content:"|560e 31c0 b03b 8d7e 1289 f989 f9|";
classtype:attempted-admin; sid:289; rev:4;)

alert tcp $EXTERNAL_NET any -> $HOME_NET 110 (msg:"POP3 EXPLOIT qpopper overflow";
flow:to_server,established; content:"|E8 D9FF FFFF|/bin/sh"; reference:bugtraq,830;
reference:cve,CAN-1999-0822; classtype:attempted-admin; sid:290; rev:5;)

```

Figure 44: Sample Snort Rule File

Snort rules are stored in individual rule files in the `/snort/rules` directory and are divided into two main sections: the rule header and the rule options.

Rule Headers

The rule header contains the action to be taken by the rule, the rule's protocol, its source and destination IP addresses and netmasks, and port information for the source and destination IP addresses. (For each sample rule shown in Figure 44, the header is the part of the command line up to the first parenthesis.)

Rule Options

Rule options are found in the second part of a Snort rule (the part within parentheses). The rule option contains the alert message Snort will display/log and information about which part of the packet should be analyzed to determine whether any action should be taken.

The rules files distributed with Snort can detect more than 1200 types of scans and attacks. The Snort community is usually the first to publish new rules, giving organizations with Snort an edge over organizations with proprietary IDS alone. Many companies will run both Snort and a proprietary IDS, increasing their coverage and defense in depth.



Snort Disadvantages

Since it is capturing all network packets, can produce large log/alert files—can be difficult to cull through vast amount of information

Console machine generally must be quite powerful, similar to a workgroup server

If console machine goes down then multiple machines may be left unmonitored

Communication from sensors to console may increase overall network traffic levels

3.4.4 Snort Disadvantages

Information Overload

The biggest disadvantage of any network-based IDS is the problem of collecting and analyzing the potentially vast amount of log/alert files. Depending on network parameters (e.g., number of hosts, bandwidth, utilization) Snort can generate an awesome number of legitimate alerts. Before installing any network-based intrusion detection system such as Snort, incredible effort must be taken to baseline the network on two separate criteria:

- **Network Traffic Volume**
In order to properly determine the minimum hardware requirements for the network sensors and analysis machines, network traffic volume must be taken into account. For example, the traffic generated by 100 hosts on a 100 Mb/s link will dwarf the traffic on a network with fewer nodes or less bandwidth.
- **Network Protocol Variety**
To further reduce the burden on your personnel and machinery, a comprehensive analysis of the observed network protocols should be performed. Once this is accomplished, it will be easy to select only those intrusion signatures that apply to your network traffic, thereby minimizing the number and size of the alerts and log files.

A popular solution for managing the vast amount of data generated is to redirect Snort's output into an SQL database. While this will aid in analyzing and trending the alerts, a tremendous amount of space is still required to support this database.

Analysis Console

Given today's modern networks, it is highly atypical to find a flat network infrastructure. Typically, network administrators will attempt to reduce exposure to vulnerabilities by segmenting their networks. The implication for intrusion detection systems is that there must be multiple Snort sensors on every network segment that you wish to monitor. The only way to collate the data generated by these sensors is to use a central management and analysis console.

Since the central management console is doing a lot of work—collating, analyzing, and storing data—it must be a fairly powerful machine. Quite often the console must be designed as a small workgroup server rather than a user workstation. This can add significantly to the expense of deploying a network-based IDS such as Snort.

Furthermore, using a centralized management console creates a single point of failure in the intrusion analysis system. If the console is unavailable or is otherwise compromised, a large number of legitimate alerts could be lost and your ability to monitor your network in real time has been defeated.


Snort Generates Traffic

In addition to the normal level of network traffic on the segment, the monitored workstations are sending information back to the central management system. On marginal networks this may raise the level of traffic to an unacceptable level. This may also be a concern for HIDS implementations that log or alert to a central management system.

The only remedy for this problem is to ensure that the network bandwidth is suitable for naturally occurring traffic as well as the meta-traffic generated by the sensors.

Snort Disadvantages - 2

Command-line interface



```

C:\snort>snort -c snort.conf
MinTTL: 1
TTL Limit: 5
Snmp Link: 0
State Protection: 0
Self preservation threshold: 50
Self preservation period: 50
Suspend threshold: 200
Suspend period: 30
Stream reassembly config:
Server reassembly: INACTIVE
Client reassembly: ACTIVE
Reassembler alerts: ACTIVE
Ports: 21 23 25 53 80 110 111 143 513 1433
Emergency Ports: 21 23 25 53 80 110 111 143 513 1433
http_decode arguments:
Unicode decoding
IIS alternate Unicode decoding
IIS double encoding vuln
Flip backslash to slash
Include additional whitespace separators
Ports to decode http on: 80
rpc_decode arguments:
Ports to decode RPC on: 111 32771
alert_fragments: INACTIVE
alert_large_fragments: ACTIVE
alert_incomplete: ACTIVE
alert_multiple_requests: ACTIVE
telnet_decode arguments:
Ports to decode telnet on: 21 23 25 119
1331 Snort rules read...
1331 Option Chains linked into 139 Chain Headers
0 Dynamic rules
*****
Rule application order: ->activation->dynamic->alert->pass->log
--- Initialization Complete ---

--> Snort! <--
Version 2.0.0-DBRC-MYSQL-WIN32 (Build 72)
By Martin Roesch (roesch@sourcefire.com, www.snort.org)
1.7-WIN32 Port By Michael Davis (mike@datanerds.net, www.datanerds.net/mike)
0.8 - 2.0 WIN32 Port By Chris Reid (chris.reid@codecraftconsultants.com)
  
```

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Command Line Interface

Snort fills an important “ecological niche” in the realm of network security: a cross-platform, lightweight network intrusion detection tool that can be deployed to monitor TCP/IP networks of all sizes, and detect a wide variety of suspicious network traffic as well as outright attacks. Snort is useful when deploying commercial NIDS sensors is not cost efficient. Modern commercial intrusion detection systems cost thousands of dollars at minimum and may cost tens or even hundreds of thousands in some cases.

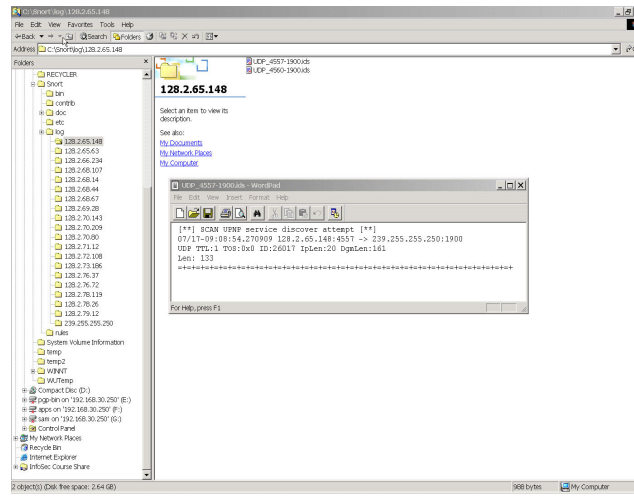
As a lightweight IDS, Snort’s main function is to capture packets and analyze them for potential security alerts. Certain user features (e.g., a GUI) were sacrificed to obtain the performance/size ratio necessary for use in an enterprise level network. The mindset of Snort’s developers was that if Snort wasn’t busy redrawing a pretty interface and managing other bells and whistles, then it would be free to perform its job better.

In order to correct this apparent deficiency, many different groups in the open-source community have created several add-on front-end GUI applications to help manage the steep initial learning curve. However, some of these advantages are not readily available since many of the front-ends and add-ons for Snort lack the comprehensive documentation that is commonplace with commercial products. As a result, Snort users turn to the myriad of Snort mailing lists²⁸ to supplement the scan instructions they find on their favorite product.

²⁸ <http://www.Snort.org/lists.html>

Snort Disadvantages - 3

Un-ordered, hierarchical output



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Unordered, Hierarchical Output

The native Snort program also deposits its alert output into a series of text files in a series of unordered, hierarchical directories. For this reason, most Snort users employ the popular database plug-in which allows you to divert the output into to one of several available SQL database products, such as

- Oracle²⁹
- MySQL³⁰
- PostgreSQL³¹
- MS SQL Server³²

When your Snort output has been redirected and stored in an SQL database, once again you will probably need to employ one of the many add-on products to help organize and analyze the alert output into useful reports. Probably the most widely used of these analytical report generators is the Analysis Console for Intrusion Databases³³ (ACID).

For comparison information regarding commercial intrusion detection systems, The NSS Group³⁴ has several free white papers on the subject.

²⁹ <http://www.oracle.com>

³⁰ <http://www.mysql.com/>

³¹ <http://www.postgresql.org/>

³² <http://www.microsoft.com/sql/>

³³ <http://www.cert.org/kb/acid>

³⁴ http://www.nss.co.uk/download_form.htm

Snort Add-Ons and Plug-Ins

To help overcome the deficiencies in Snort and the difficulties of working with a command-line program, developers have created a near cottage industry around add-ons and plug-ins, which include the following:

- IDScenter – GUI configuration utility
- ACID – PHP-based alert analysis program
- PureSecure – GUI alert analysis program
- SnortCenter – GUI configuration utility
- SnortSnarf – Perl-based alert analysis program
- Barnyard – output plug-in
- Swatch – alert filter
- Snortsam – alert filter tie-in for firewalls
- SnortFE – small Windows-based real-time alert interface
- Razorback – small Linux/Gnome real-time alert interface
- Hen Wen – Mac OSX port of Snort 2.0

3.5 Snort Add-Ons and Plug-Ins

A near cottage industry has grown up around developing add-ons and plug-ins to enhance the operation of Snort. These are some of the major enhancement products:

IDScenter³⁵ is a GUI environment developed by Engage Security designed to allow users to quickly and easily configure Snort and its operation in the windows environment. Its strengths lie in its multiple wizards which allow users to quickly and easily configure Snort. The EagleX distribution of IDScenter is a complete IDS package which installs Snort, MySQL, Apache, PHP, and ACID. Instructions for installing IDScenter will be provided in Section 3.5.2.

ACID is a GUI front-end, written in PHP, which allows users to track attack patterns and trends and historical alerts. ACID is probably the most popular add-on for analyzing and organizing Snort alert output once it has been directed into an SQL database. Section 3.5.1 contains more information about ACID.

PureSecure is a GUI environment developed by DeMarc Security³⁶ that combines IDS with host file system integrity.

SnortCenter is a GUI environment developed by Stefan Dens.³⁷ SnortCenter is written in PHP and Perl and is designed primarily to assist users in configuring Snort and keeping the signature files up-to-date.

³⁵ <http://www.engagesecurity.com>

³⁶ <http://www.demarc.com>

³⁷ <http://users.pandora.de/larc/index.html>

SnortSnarf is a PHP utility developed by Silicon Defense³⁸ is a small utility written in Perl which is designed to group Snort alerts and conveniently display them in Web pages for easy analysis.

Barnyard³⁹ is a small utility to help manage Snort's unified output.

Swatch⁴⁰ is a small alert monitoring utility written in Perl and developed by Todd Atkins. Swatch is used to monitor Snort alerts and to automate certain types of responses.

SnortSam⁴¹ is another alert monitoring utility which allows a system to respond to certain types of events by reconfiguring a firewall to block a specific source IP.

SnortFE⁴² is a Windows-based GUI front end developed by Anthony Scalzitti for quickly displaying Snort real-time alerts.

RazorBack⁴³ is a small GUI front end developed by Intersect Alliance. RazorBack runs only in the Linux/Gnome environment and is used for quickly displaying real-time alerts.

HenWen⁴⁴ is a Mac OS X port of Snort 2.0 developed by Nick Zitzmann. (This IDS is named for the character Hen Wen, an oracular pig who appeared in Lloyd Alexander's novel *The Black Cauldron* as well as in the Disney movie of the same name.)

³⁸ <http://www.silicondefense.com>

³⁹ <http://www.snort.org/dl/barnyard>

⁴⁰ <http://www.oit.ucsb.edu/~eta/swatch>

⁴¹ <http://www.snortsam.net/index.html>

⁴² <http://security.scalzitti.org>

⁴³ <http://www.intersectalliance.com/projects/RazorBack/index.html>

⁴⁴ http://www.snort.org/dl/contrib/front_ends/henwen/



ACID (Analysis Console for Intrusion Databases) for Snort

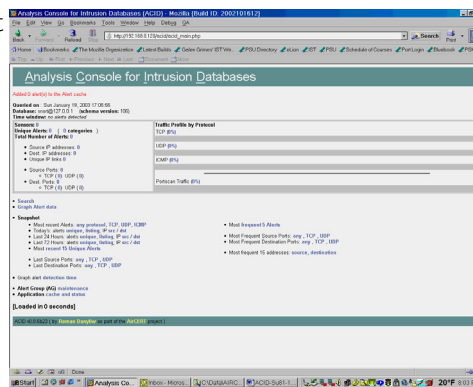
GUI front-end for Snort

Written in PHP

Employs a SQL database as an alert repository

Used to identify attack trends

www.cert.org/kb/acid



Demo: ACID

© 2003 Carnegie Mellon University

Module 3: Intrusion Detection—Slide 13

3.5.1 Analysis Console for Intrusion Databases (ACID)

ACID was written by Roman Danyliw, an analyst at the CERT Coordination Center of the Software Engineering Institute. ACID is a set of PHP scripts designed to function as a conduit between a Web browser and the SQL database storing Snort alerts and is designed to show attack patterns and trends by organizing the alerts according to queries initiated by the user. The queries can be based on any number of network specific parameters such as attacker's IP address, the time and/or date of the attack or time range, the destination IP of the attack, or the type of attack.

Unfortunately, as with most open source products, ACID lacks much documentation on how to install and use the product. Originally developed on Linux, it now runs on Linux, Windows, most variations of UNIX, and the Mac OS X operating system.

Some installation instructions for the Windows version can be found at the Silicon Defense Web site.⁴⁵ Most users turn to the Snort mailing lists⁴⁶ for technical support and instructions.

On its opening screen ACID displays preconfigured queries for trend analysis information most commonly sought by Snort users—most recent alerts (by protocol), today's alerts, alerts in the last 24 or 72 hours, 15 most recent unique alerts, etc.

⁴⁵ <http://www.silicondefense.com/>

⁴⁶ <http://www.snort.org/lists.html>

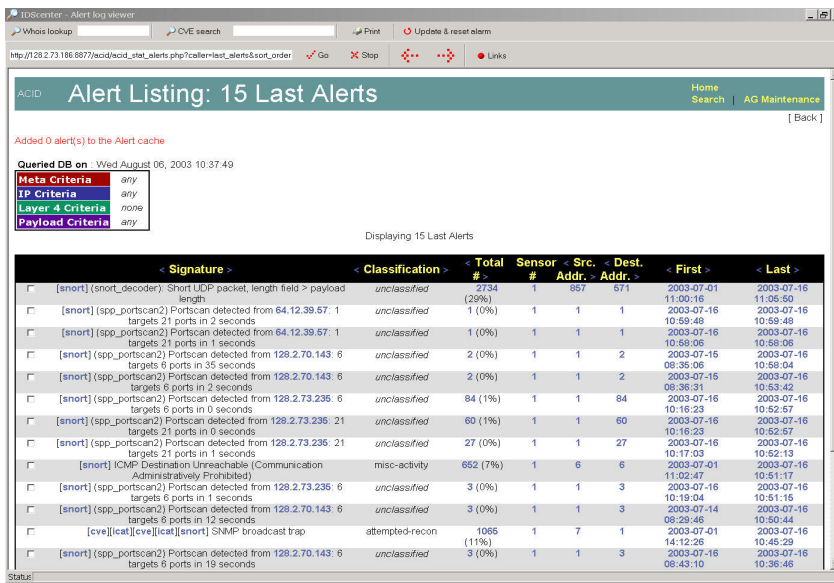


Figure 45: ACID Alert Listings

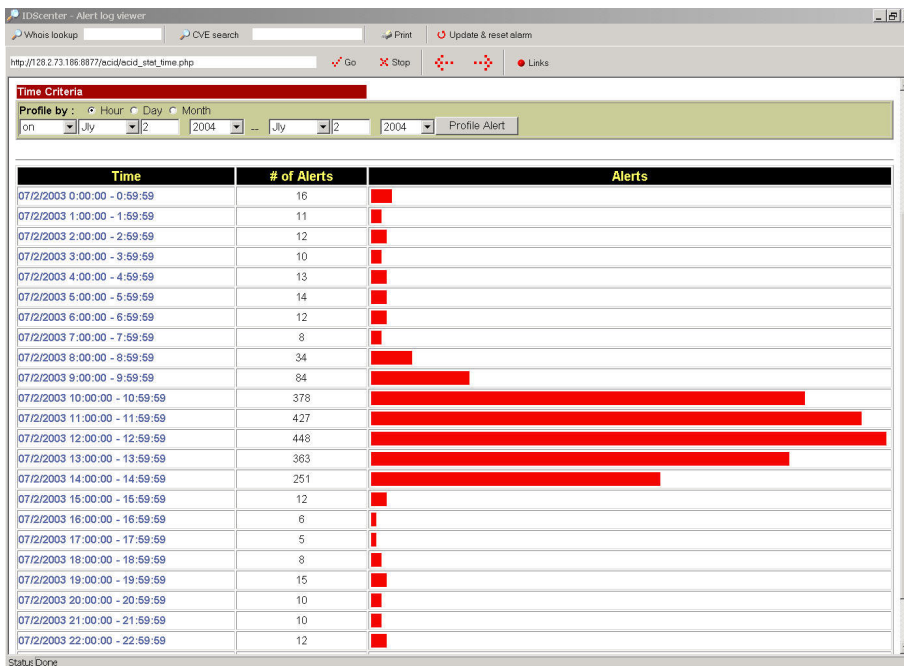


Figure 46: ACID Attack Trend Analysis

ACID also has rudimentary graphics capabilities (see Figure 45 and Figure 46) which allow users to graph certain trend patterns such as a display of alerts broken down by time (e.g., hour, day, or month). For example, to graph alert detection times over a 24 hour period you can select the graph alert detection time link and then enter the month, day, and year for the alerts you want to be graphed.

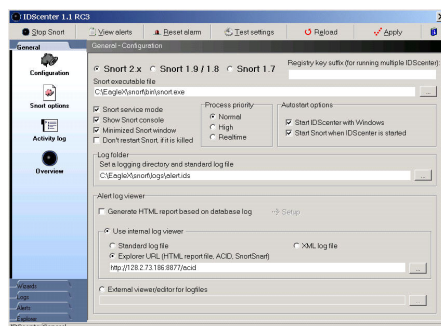
IDScenter for Snort

GUI front-end for Snort

Used to configure Snort in a Windows environment, and to keep signature files up-to-date

Includes ACID in the Eagle X distribution

www.engagesecurity.com



Demo: EagleX

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3.5.2 IDScenter

Engage Security’s IDScenter, a GUI front end for Snort written and maintained by Ueli Kistler, makes it easier for users to configure Snort and the operating system environment. IDScenter is only available for the Windows platform.

Installing IDScenter

1. Download EagleX from the Engage Web site⁴⁷ and save it to your computer.
2. Read the *Snort IDScenter 1.1 Manual* [Kistler 03].
3. Wherever you install the EagleX program, make sure that the path does not contain any space characters, or else Snort will fail to start.
4. Next, the installer will install WinPcap. Remember to reboot after install so that the latest version will be used.
5. Next, the EagleX configuration screen will open. Enter IDS box IP address into the “DNS/IP” field, port 8877, and the other fields as appropriate and then set up.
6. After it is installed, the program is running but you will not see the GUI. An icon in the system tray shows that the program is running even though the GUI is not open. Double click the icon and the GUI will open. In the upper left, if you see a button labeled “Stop Snort,” that means that Snort is currently running.

Through a series of wizards, IDScenter allows users to control all aspects of Snort—network variables, preprocessors, rules changes/configuration, network variables, preprocessors,

⁴⁷ <http://www.engagesecurity.com/>

output plug-ins, online updates, etc., without having to manually edit the Snort configuration file, `snort.conf`.

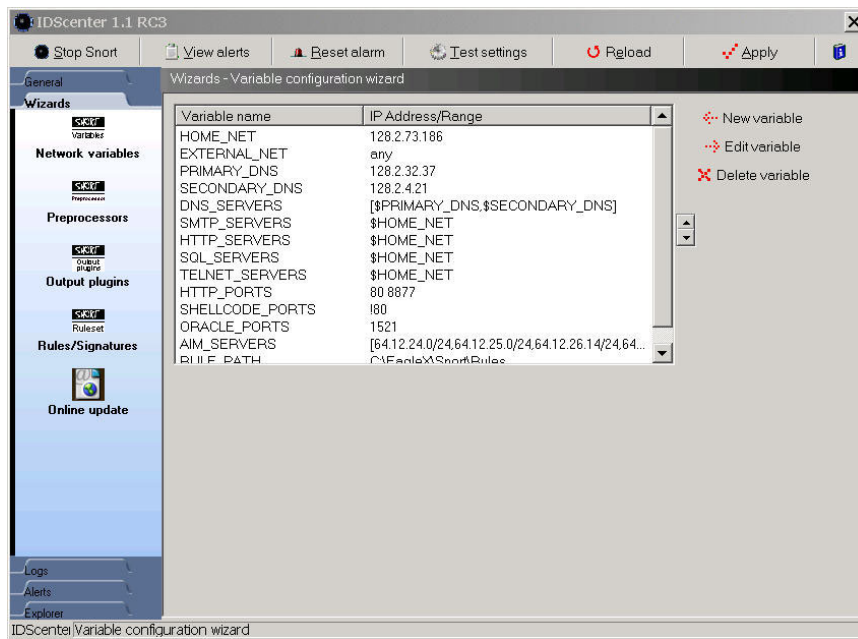


Figure 47: IDScenter Network Variables Wizard

IDScenter Network Variables Wizard

This is where the actual IPs and/or hostnames, ports, and paths for the subnet and various servers are assigned to the system variables which run in the operating scripts and attack signatures. These need to be configured correctly in order for the rules to work most effectively with the different types of servers which may be running on the network.

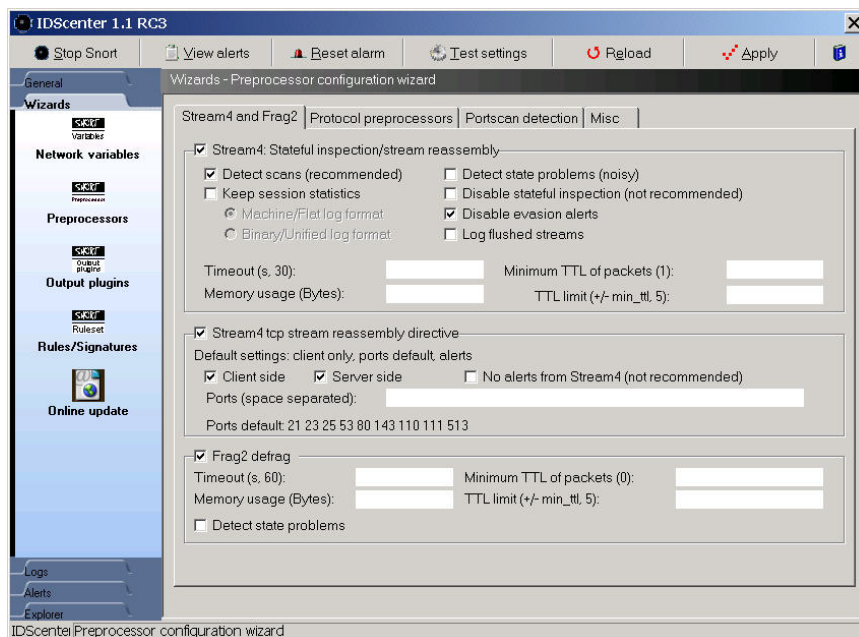


Figure 48: IDScenter Preprocessor Wizard

IDScenter Preprocessor Wizard

Snort preprocessors can be configured to handle packets in an out-of-band manner before the detection engine is called. These preprocessors can help manage how HTTP is decoded, portscans are handled, fragmented packets are reassembled, and several other functions. For more information, read the *Snort User's Manual*,⁴⁸ which is included as a PDF in the Snort directory when the package is installed under EagleX.

⁴⁸ <http://www.snort.org/docs/SnortUsersManual.pdf>

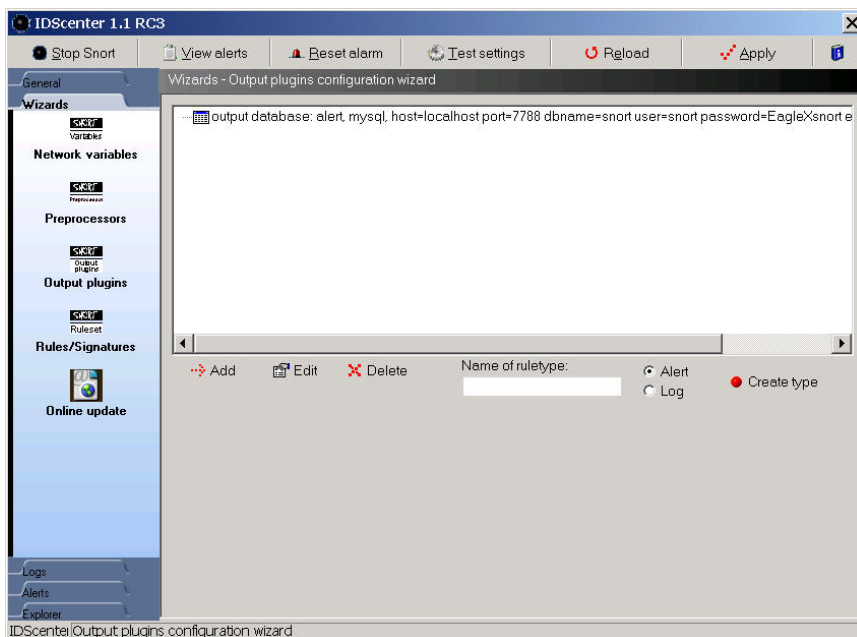


Figure 49: IDScenter Output Plugin Wizard

There is limited information regarding the output plug-ins, but two good resources are the *Snort User's Manual* and the *Snort IDScenter 1.1 Manual* [Kistler 03].

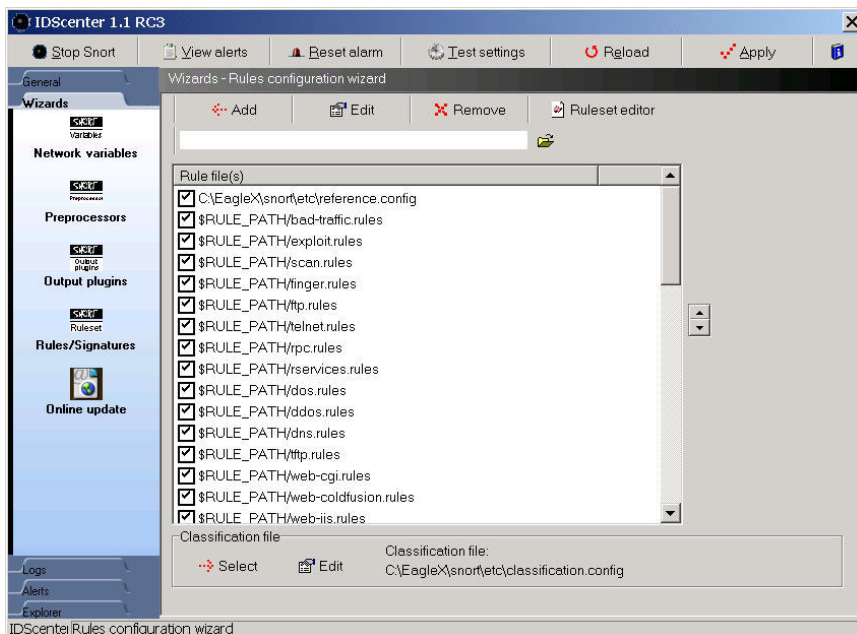


Figure 50: IDScenter Rules/Signatures Wizard

IDScenter Rules Wizard

The rules wizard shown in Figure 50, along with the ruleset editor, allows users to easily edit and configure the signature rules used to recognize attacks. This is also where an administrator can customize the ruleset by adding or removing rules (signatures) specific to the needs of their network.

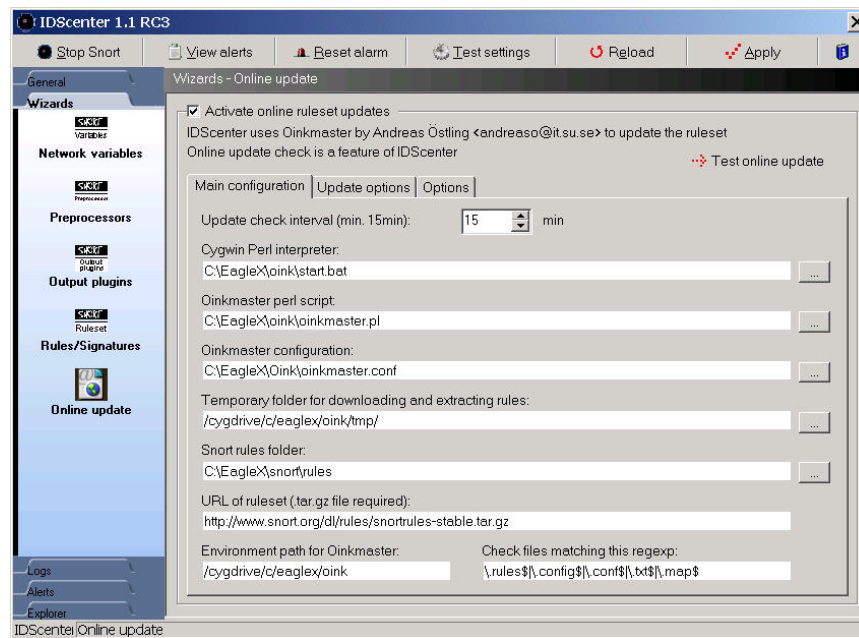


Figure 51: IDScenter Online Update Wizard

IDScenter Online Update Wizard

The online update wizard is how administrators would update the Snort rules file from <http://www.snort.org/rules> when new rules are released for newly discovered attacks or threats. IDScenter uses another add-on, Oinkmaster, to do the rules updates. To use the online update feature, just make sure the Activate Online Ruleset Update feature on the online update wizard screen is checked. The program will check <http://www.snort.org/rules> every 15 minutes (or whatever interval you choose) to see if new rules have been updated.

The paths that start with: `/cygdrive/c` may only work if Cygwin is installed on the Windows machine to simulate a UNIX-style environment. If you do not have Cygwin installed, you must create two temporary directories for the online update to work properly. The first directory—`C:\EagleX\tmp`—is where the rules are downloaded, opened, and installed from. After the installation process is complete, they are deleted. The second directory you create—`C:\EagleX\RuleBackups`—is where old rule sets are backed up before the newly downloaded rules are installed. On the Options tab, we need to change the directory for rule backups from “`C:\temp`” to “`C:\EagleX\RuleBackups`.” Click on the Apply button at the top of the screen to apply the changes. Then, click the Test online

update button. You will get a console screen that will show all of the rules that have been disabled or added, the non-rules that have been modified, and the files that have been added. If you run it again immediately afterward, you will see that nothing gets modified on the second try. This demonstrates that the first online update probably worked correctly.

The issue with updating Snort rules is that if you manually disable the Snort rules that you don't use or don't need, the online update enables all of those rules again so you will have to go back and disable them each time that new rules are added. The Oinkmaster program overcomes this by not including the unwanted rules in the update process. On the Update options tab there is a place where you can choose which rule sets to skip, thereby avoiding having the update process re-enable these rules.⁴⁹

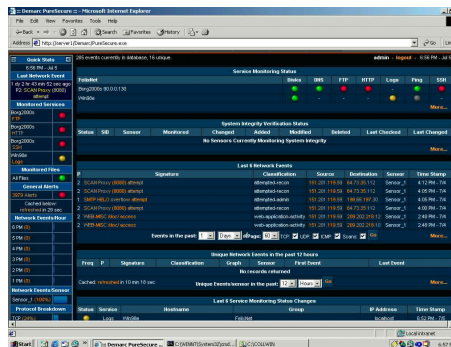
⁴⁹ <ftp://ftp.it.su.se/pub/users/andreas/oinkmaster/docs/README>

PureSecure for Snort

GUI front-end for Snort

More complete IDS than other GUI front-ends

Used to gather real-time alerts, attack trends, and to monitor host system file integrity



Demarc PureSecure

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3.5.3 PureSecure

Demarc PureSecure offers both a free version and a commercial version of its IDS console that provides additional capabilities to Snort as well as a nice graphical user interface. It uses Snort as its IDS engine, MySQL as its database, and Apache as its Web server platform. Much of the program is written in PERL and CGI and this code can be viewed in the Linux/UNIX distribution.

The PureSecure features below have been extracted from <http://www.demarc.com>:

- network intrusion detection system (NIDS) management console, integrating the raw power of the Open Source Snort IDS engine with the convenience and power of a centralized interface for all network sensors.
- monitor all servers / hosts to make sure network services such as a mail or Web servers remain accessible at all times.
- monitor local processes on a host and optionally restart them if they terminate unexpectedly.
- monitor system logs looking for anomalous log entries that may indicate intruders or system malfunctions.
- distributed file integrity checking that allows not only for immediate discovery of files that have been tampered with but also an additional level of security over standard file integrity checkers because the “known good” data is stored in the central database away from the potential intruder of a specific host.

- multilevel authentication to allow different users access to specific configuration options, or “monitoring” only accounts, which only allow viewing of the aggregate data.
- advanced search and graphing capabilities that allow operators to easily extract useful information from the NIDS data, facilitating an efficient and effective investigation into possible intrusion attempts and trends.
- complex alerting capabilities that allow for highly specific alert settings for all areas of the software, so that you only get paged for the events you chose.
- integrates all necessary security software into an all-inclusive centralized management console.

PureSecure is distributed on the Windows platform (e.g., NT/200/XP), Linux and virtually every version of UNIX.

To install PureSecure, download and execute the script file (for UNIX or Linux) or the installation executable (for Windows). You will be prompted during the installation for configuration names and installation directories. Since DeMarc distributes a commercial version of PureSecure, the documentation is very complete.

PureSecure compares favorably to ACID as an analysis tool. Since both allow users to perform sophisticated queries on the alert database. ACID may have a slight edge on the number of preconfigured queries you can perform through links on the opening page. As an IDS tool, PureSecure has the edge on ACID since PureSecure can also perform file integrity checks on host systems and monitor specific services (e.g., DNS, POP3, SMTP, etc.) on your network.

IDS: Tripwire

Host-based

Designed to monitor the state of the operating system of a host by validating the integrity of files and folders

Windows version: commercial product

POSIX compliant version: open source product

<http://www.tripwire.com>

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3.5.4 Tripwire⁵⁰

The following paragraph is excerpted from the *Red Hat Reference Guide*.⁵¹

Tripwire data integrity assurance software monitors the reliability of critical system files and directories by identifying changes made to them. It does this through an automated verification regimen run at regular intervals. If Tripwire detects that a monitored file has been changed, it notifies the system administrator via email. Because Tripwire can positively identify files that have been added, modified, or deleted, it can speed recovery from a break-in by keeping the number of files which must be restored to a minimum. These abilities make Tripwire an excellent tool for system administrators seeking both intrusion detection and damage assessment for their servers.

Initializing Tripwire

Like every intrusion detection system mentioned during this module, Tripwire will need a fair amount of configuration to adequately protect the system.

The installation script creates default policy and configuration files stored in the `/etc/tripwire` directory as `twpol.txt` and `twcfg.txt`. These files are in cleartext and need to be removed from the system as soon as the encrypted versions are in place for obvious security reasons.

⁵⁰ <http://www.tripwire.com>

⁵¹ <https://www.redhat.com/docs/manuals/linux/RHL-9-Manual/ref-guide/ch-tripwire.html>

The default policy probably includes monitoring for a number of files not present on the local system, so it's important to trim these files out of policy. The following procedures will illustrate exactly how this is done.

The default policy should be installed using the command as root:

```
% /usr/sbin/twadmin -m P /etc/tripwire/twpol.txt
```

Next, generate the initial database using the following command as root:

```
% /usr/sbin/tripwire --init
```

Customizing Tripwire

Once an initial database is created, some customization is necessary to prevent the issuance of a large number of false alarms. These false alarms occur any time there is a discrepancy in the default policy and the local system's current configuration. To generate a listing of the discrepancies between the local system and the default policy, issue the following command as root:

```
% /usr/sbin/tripwire --check
```

Note that this command will also take several minutes to complete. Once this listing has been generated, edit the policy file, `/etc/tripwire/twpol.txt`, and comment out or delete each of the filenames that were just returned.

Additionally, there are other files in the default policy that may not make sense to monitor on the local system. These include lock files (which identify that some process is in use) and pid files (which identify the process ID of some daemons). Since the files are likely to change often, if not at every system boot, they can cause Tripwire to generate false positives. To avoid such problems, comment out all of the `/var/lock/subsys` entries as well as the entry for `/var/run`.

Finalizing the Tripwire Configuration

Any time the tripwire policy file is edited, the policy needs to be reinstalled and the database will need to be recreated. As before, these tasks are accomplished by issuing the following commands as root:

```
% /usr/sbin/twadmin -m P /etc/tripwire/twpol.txt  
% /usr/sbin/tripwire --init
```

Files/Directories to Monitor

As a starting point, here are some files that may be of interest to Tripwire. The following list is not intended to be comprehensive, nor is it a one-size-fits-all solution. Depending on system usage parameters, many files will need to be added (or deleted) during Tripwire configuration.

Table 3: Files and Directories to Monitor

Root's Home	The OS Kernel	Critical Boot Resources	Critical Directories and Files	Other Popular Filesystems	Unusual Directories
/root /root/.bash_history	/boot/vmlinuz	/boot	/chroot /etc /etc/inetd.conf /etc/nsswitch.conf /etc/rc.d /etc/mtab /etc/motd /etc/group /etc/passwd	/usr /usr/local /dev /usr/etc	/proc /tmp /mnt/cdrom /mnt/floppy



Tripwire Advantages

Relatively easy to deploy and to manage

- Only one machine is involved
- Requires only one administrator
- Creates single source of log and alert information

Not resource intensive (often will not require CPU, memory, etc. beyond what is needed for OS and applications)

Central console for monitoring up to 2,500 machines with Tripwire installed (commercial version)

Open source version available POSIX-compliant operating systems (www.tripwire.org)

Tripwire Advantages

Since it has only a handful of command line options, Tripwire is relatively easy to use. After the upfront configuration of the policy file has been completed, a simple cron job run nightly can perform monitoring on a host system.

Normally, the program is not CPU or memory intensive, but will tie up the hard disk while it is operating since it is scanning the files and directories designated by the administrator.

Tripwire should initially be run on a pristine system to establish a baseline database. A pristine system is usually defined as the condition of a system immediately after the operating system has been installed and thoroughly patched, along with any service applications the administrator intends to run. A pristine system should not be connected to the Internet or to a local area network until after the baseline database has been established by Tripwire. Once the baseline database has been established, subsequent operation of Tripwire can establish how the system differs from the baseline.



Tripwire Disadvantages

If the host is compromised, Tripwire may cease to function and thus no more alerts will be generated

Works well for single machine; extremely labor-intensive to monitor multiple machines running individual copies of Tripwire (open-source version)

GUI only available on commercial version (www.tripwire.com)

Demo: Tripwire

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Tripwire Disadvantages

Tripwire can easily manage one host machine, but because the entire operation from start to finish has to be duplicated on each subsequent host computer, it quickly becomes extremely labor-intensive to run Tripwire on a large number of host computers, at least for the initial setup of the program.

The only way to get around this shortcoming is to have a standard baseline. In other terms, administrators may find that using a standard “new machine” image can greatly reduce the amount of time needed to generate system baselines tasks. Administrators could baseline only the image, and then copy that image onto all new machines thereby only creating the Tripwire database once.

Like any other integrity management system, the effectiveness of Tripwire is eliminated if the host computer is compromised. As with any other IDS, the host computer on which it is installed should be hardened according to conventional practices.

IDS: LANguard System Integrity Monitor (SIM)

Host-based

Designed to monitor the state of the operating system of a host by validating the integrity of files and folders

Windows-based product: freeware

<http://www.gfi.com/languard>

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3.5.5 LANguard System Integrity Monitor (SIM)

LANguard SIM is another host-based IDS similar to Tripwire. The major difference between LANguard SIM and Tripwire are that LANguard SIM comes with a Windows-based GUI interface which allows for much easier configuration and a reduced learning curve.

LANguard SIM also allows users to easily set multiple integrity file groupings and to schedule periodic integrity checks (see Figure, The LANguard Scheduling Dialog Box) and automatically alert administrators of detected discrepancies.

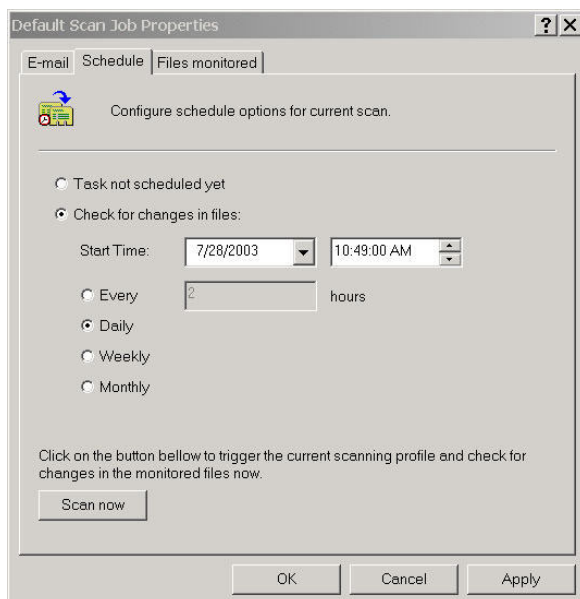


Figure 52: The LANguard Scheduling Dialog Box

Table 4: Files/Directories to Monitor with an IDS

Boot files	C:\Config.Msi C:\IO.SYS C:\MSDOS.SYS C:\NETDETECT.COM C:\NTLDR C:\pagefile.sys
General OS Files	C:\WINNT\3CWMUNST.EXE C:\WINNT\DELTSUL.EXE C:\WINNT\DISCOVER.EXE C:\WINNT\euroconv.inf C:\WINNT\explorer.exe C:\WINNT\hh.exe C:\WINNT\ieuninst.exe C:\WINNT\IsUninst.exe C:\WINNT\notepad.exe C:\WINNT\Q330994.exe C:\WINNT\REGEDIT.EXE C:\WINNT\ShellIconCache C:\WINNT\TASKMAN.EXE C:\WINNT\ttuninst.exe C:\WINNT\TWUNK_16.EXE C:\WINNT\TWUNK_32.EXE C:\WINNT\UnGins.exe C:\WINNT\uninst.exe C:\WINNT\unvise32.exe C:\WINNT\UPWIZUN.EXE C:\WINNT\WELCOME.EXE C:\WINNT\WINHELP.EXE C:\WINNT\winhlp32.exe C:\WINNT\winrep.exe C:\WINNT_DEFAULT.PIF
Core OS Files	C:\WINNT\SYSTEM32
Application DLL files	C:\WINNT\SYSTEM32\DLLCACHE



LANguard SIM Advantages and Disadvantages

Advantages:

- GUI interface
- Scheduled/automated scans and alerts
- Relatively easy to deploy and to manage
- Not resource intensive

Disadvantages

- Works well for single machine; extremely labor-intensive to monitor multiple machines running individual copies of Languard SIM
- If the host is compromised, LANguard SIM may cease to function and thus no more alerts will be generated

Demo: LANguard

LANguard SIM Advantages and Disadvantages

LANguard SIM is a host-based IDS for Windows that works on the same principle as Tripwire but is probably easier to use because it has a GUI interface. Once installed on a pristine system, the administrator runs LANguard to establish a baseline database. One major advantage LANguard has over Tripwire is the ability to schedule periodic checks of the host system against the baseline database. LANguard also allows the administrator to establish multiple baseline databases (i.e., scan jobs) allowing the administrator to check specific files and/or directories.

Like Tripwire, LANguard is not resource intensive and works quite well on a single system, but it becomes labor-intensive to use to monitor multiple host computers.

Using LANguard

To use LANguard, first download and install the program. You can examine how it operates by using the Default Scan Job. The Default Scan Job is a sample integrity check.

Start LANguard. In the GFI LANguard System Integrity Monitor, open Scan Jobs > Default Scan Job.

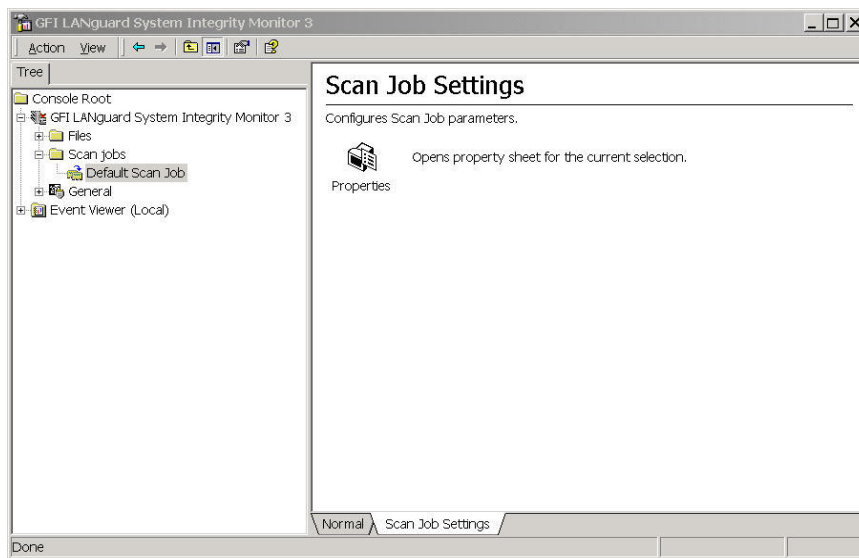


Figure 53: LANguard Scan Job Settings

Right click on the Default Scan Job and select Scan Now.

LANguard SIM should begin the scan of the host computer. When the scan is completed you can examine the results in the local Event Viewer by opening the GFI LANguard System Integrity Monitor.

To see how LANguard works, drill down in the C: section of the Files section. Create a small text file using Notepad and save the file in one of the scanned directories.

Now run the Default Scan Job again and then check in the Event Viewer again to see if LANguard detected the additional file you created.

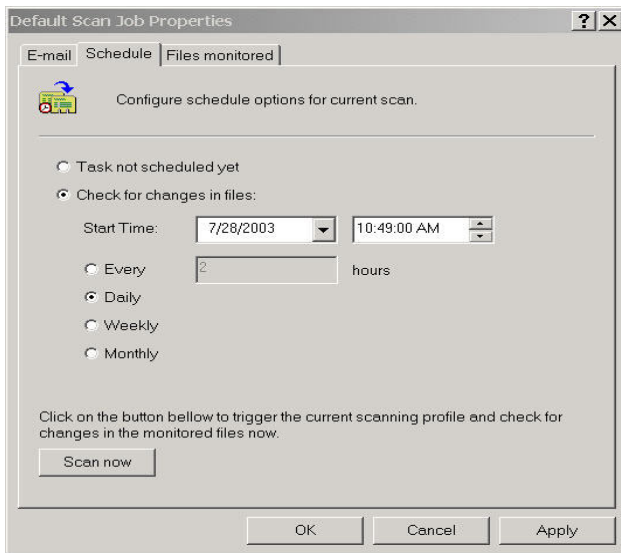


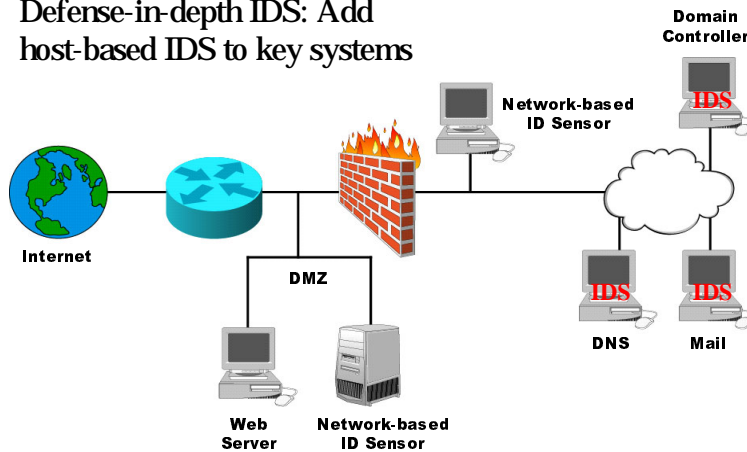
Figure 54: LANguard Scheduler

To schedule periodic scans of your files, right click on the scan job, either the Default Scan Job or scan jobs you create, and select Properties. Then click on the Schedule tab and select the frequency by which you want to check your files.



How do you deploy your IDS?

Defense-in-depth IDS: Add host-based IDS to key systems



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3.6 Deploying the IDS

Since you will be using more than two sensors on your network these sensors should be deployed as shown here with your primary IDS sensor monitoring outside your firewall and your secondary IDS sensor monitoring all traffic inside your firewall. If a critical LAN within the intranet needs to be protected, then a network sensor should be placed at the entry point to that LAN in the DMZ, between the external router and the firewall to monitor the external segment.

In addition, a sensor should be placed inside the firewall to monitor the innermost network segment and to monitor traffic passing through the firewall to make sure that the traffic inside the firewall is the traffic expected on the LAN. The only traffic you should expect to see inside your firewall is the traffic generated by the hosts and services running on your LAN.

The remaining sensors should be host sensors that are loaded onto critical servers, such as file servers, Web servers, and mail servers.

You should not place a sensor outside your Internet firewall unless you intend to use it for gathering statistics about attacks. Outside your Internet firewall is all the malicious Internet traffic you have configured your firewall to block. However, the IDS does not know about this firewall, so will alert on everything, regardless of whether or not the traffic will actually make it into your LAN.



IDS Deployment Problem 1: Collecting Data on High Speed Network Backbones

Bandwidth is increasing—most network IDS can not keep up with data rates approaching 1 Gbps, let alone 10 Gbps or higher.

Faster hardware, more powerful host computers needed

Additional IDS sensors in larger, segmented network

Network protocols need to be fully understood

Eliminate signatures for detecting unused protocols

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3.6.1 IDS Deployment Problem 1

One major problem administrators face in deploying an IDS is making sure it can keep up with the ever increasing bandwidth of modern networks. It is not uncommon for network backbones these days to use pipes capable of data rates in the 1–10 Gbps range. It is also becoming increasingly more common to see network speeds like these extending down to the desktop. Snort can handle 100 Megabit speeds comfortably. With anything faster, special care must be taken to optimize or turn off the preprocessors and optimize the packet capture library. A specially tuned Snort installation running a specially turned packet capture library may be able to hit speeds of up to 350 Megabits per second. However, most non-specialty Snort installations will drop approximately 50% of the packets at this speed [Caswell 03].

For an IDS to be effective it must be able to capture all packets on these high speed networks and analyze them in real time. To a certain extent, hardware and software must be designed to handle this ever increasing demand which means faster, more powerful host computers used as IDS. For a small network with a flat topology, this may be the answer. For larger, more segmented networks, the number and placement of IDS sensors should be taken into account when designing and/or adding hosts and services to the network. Conversely, the decision of where to place new hosts and services should take into account the capacity of the existing sensors. These can also be factors to consider when deciding whether to increase bandwidth on a network. While it may be nice to have large bandwidth (greater than 100 Megabits per second), there may also be a greater need to not overwhelm the capacity of the IDS.

When the IDS resources have been maximized, however, the only remaining solution is to reduce the amount of traffic that is analyzed. This can be accomplished by minimizing the services that are running on the network to only the necessary services, in accordance with the best practices of system hardening. Because the IDS must inspect all packets, it must understand a vast number of network protocols. This factor must be taken into account when the attack detection signatures are created. Also, it is important in most network implementations to block certain protocols and certain types of traffic that have no legitimate presence on the protected network.

Network administrators need to be aware of what protocols the IDS is set to monitor and should not have the IDS configured to detect protocols that will never appear on the network. For example, if the network administrator does not have any Windows based servers or workstations on the network segment there is little use in monitoring NETBIOS traffic. Thus, it is important for the administrators to have a thorough understanding of what is running on their network so that they can make intelligent decisions regarding which signatures to include and exclude. By removing unneeded signatures administrators can improve the performance of the IDS as it will have less traffic to closely inspect.



IDS Deployment Problem 2: Keeping Signature Data up to Date

IDS signatures are like anti-virus definitions—must be kept up to date in order to recognize new threats

Snort signature files can be found at
<http://www.snort.org/dl/rules/>

Customized Snort signature files (rules) can also be written by users

Demo: Rules

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3.6.2 IDS Deployment Problem 2

The rate at which new network attacks are being developed is steadily growing. As a result, new IDS signature rules must be developed to update IDS detection tools. This is the same problem faced by anti-virus vendors and network administrators in trying to keep up with A-V attacks. It is a challenge to keep the systems up to date in preparation for new attack scenarios.

Snort comes with signature (rules) files that can detect more than 1200 types of attacks. Snort rules files are stored in the `/snort/rules` directory. In addition, the rules language (like the Snort IDS engine) is open source, allowing administrators to write new rules or customize existing rules.

New rules can be downloaded from <http://www.snort.org/dl/rules/> and information on each rule along with documentation can be downloaded from <http://www.snort.org/snort-db/>.

A typical Snort rules looks something like this:

```
alert icmp $EXTERNAL_NET any -> $HOME_NET any (msg:"ICMP ISS  
Pinger"; content:"|495353504e475251|"; itype:8; depth:32;  
reference:arachnids,158; classtype:attempted-recon; sid:465; rev:1;)
```

Snort rules are divided into two main sections—the rule header and the rule options. The header contains the action to be taken by the rule, the rule's protocol, its source and destination IP addresses and netmasks, and the source and destination IP addresses ports information.

In the above example the header is the part of the command line up to the first parenthesis.

The second part of a Snort rule is the rule option section. The option section contains the alert message Snort will display/log and information on which part of the packet should be analyzed to determine if any action should be taken.

Just as important is optimizing the installed ruleset to make sure that rules are not loaded that do not pertain to your existing network setup. Snort rules are loaded through the `snort.conf` file, a portion of which is shown below:

```
#=====
# Include all relevant rulesets here
#
# shellcode, policy, info, backdoor, and virus rulesets are
# disabled by default. These require tuning and maintance.
# Please read the included specific file for more information.
#=====

include $RULE_PATH/bad-traffic.rules
include $RULE_PATH/exploit.rules
include $RULE_PATH/scan.rules
include $RULE_PATH/finger.rules
include $RULE_PATH/ftp.rules
# include $RULE_PATH/telnet.rules
include $RULE_PATH/rpc.rules
include $RULE_PATH/rservices.rules
include $RULE_PATH/dos.rules
include $RULE_PATH/ddos.rules
include $RULE_PATH/dns.rules
include $RULE_PATH/tftp.rules
. . .
```

To exclude certain rules you comment out the line by preceding it with a pound sign “#”. You can edit `snort.conf` manually or use one the many available ruleset editors such as the one you find in IDScenter.

For example, Snort contains a rule to monitor attacks against POP3 mail servers. If you do not have a POP3 mail server operating on your network, it makes no sense to have that rule loaded.

If you are using the rules/signature wizard in IDScenter to manage your rules you could simply uncheck the rules you did not want Snort to load. In Figure 55, rules have been unchecked for the following:

- Web-frontpage
- netbios
- Oracle
- SNMP

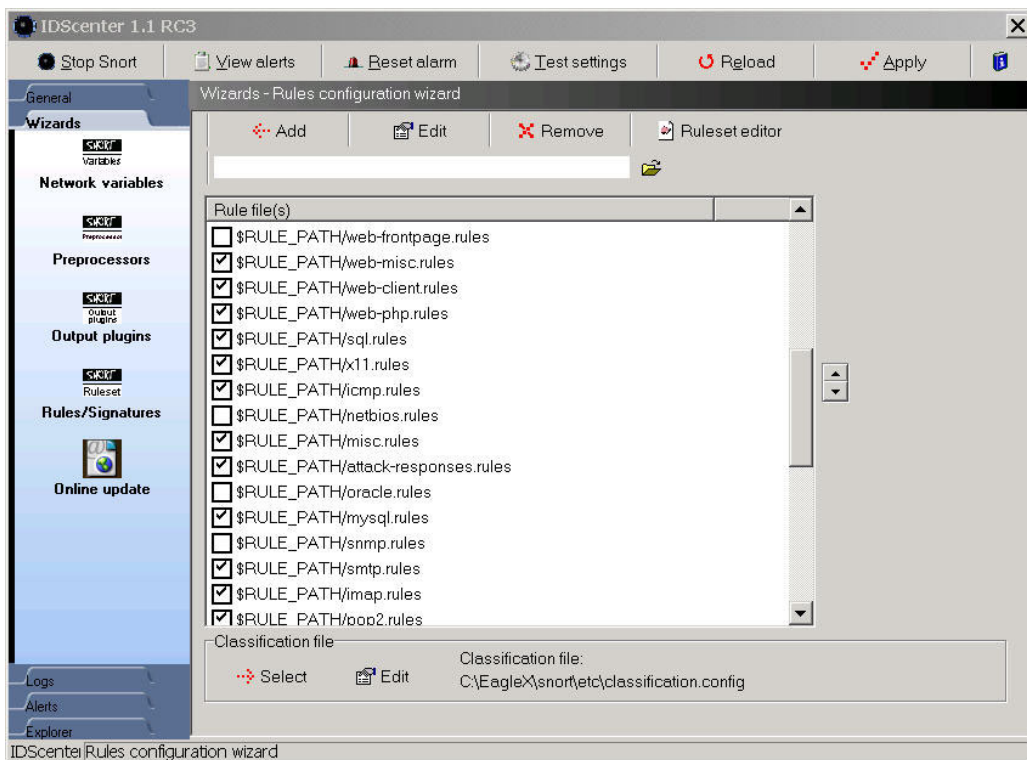


Figure 55: Selecting Snort Rulesets in IDScenter

You can likewise use the rules editor in the rules/signature wizard to edit existing rules. To edit a new rule simply highlight the rule you want to edit and select the ruleset editor button at the top of the dialog box. The ruleset editor will open displaying the contents of the selected rule.

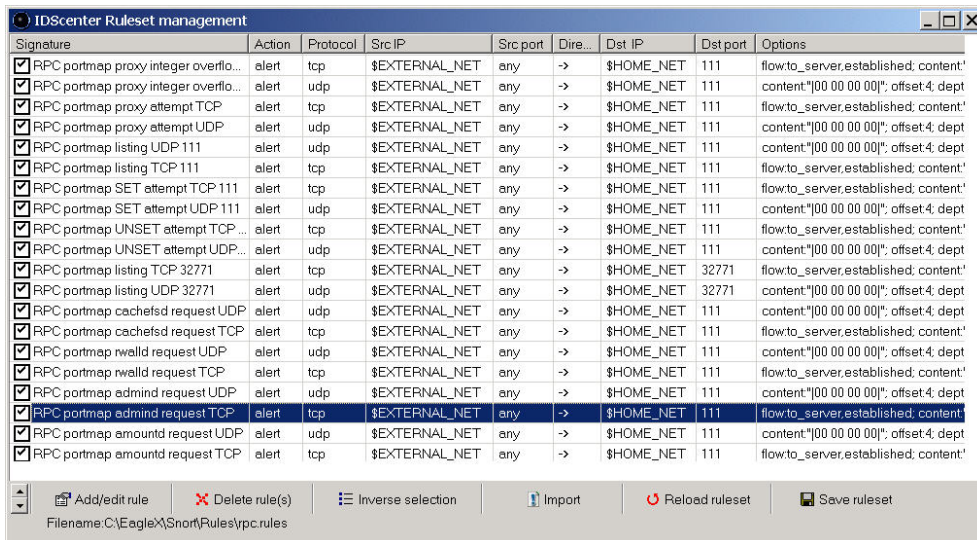


Figure 56: Editing Individual Rules in IDScenter

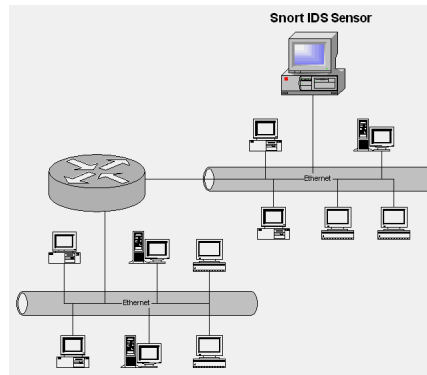


IDS Deployment Problem 3: Can Only Collect Local Traffic

IDS can only collect data on local network segment.

Most only work on hubs, or if on a switch must be connected to maintenance port.

To monitor multiple segments, you can install multiple NICs in IDS or use multiple IDS.



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3.6.3 IDS Deployment Problem 3

A collision domain is a logical area in a computer network where data packets can “collide” with one another, in particular in the Ethernet networking protocol. A collision domain can be a single segment of Ethernet cable in shared-media Ethernet, or a single Ethernet hub in twisted-pair Ethernet, or even a whole network of hubs and repeaters.⁵²

As collision domains become more and more segmented through the use of switching technology the deployment of NIDS becomes more challenging since NIDS cannot capture packets through a normal switch port, but can capture them through a hub. Most organizations use switches now instead of hubs, so deployment of NIDS end up on the span port (often called drain port or maintenance port) of each switch. Likewise, since routers are used to segment collision domains, NIDS do not collect all packets going through routers.

Solution: Use More Than One IDS or Multiple NICs in the IDS

The solution is to install a NIDS on each segment you need to monitor or to place multiple NICs (network interface cards) into each NIDS. To gain the big-picture perspective, all of the alerts from these individual NIDS should (as a best practice) be compiled onto a single management system. This level of analysis can be a challenge for administrators, but will better enable them to holistically evaluate the security state of their networks.

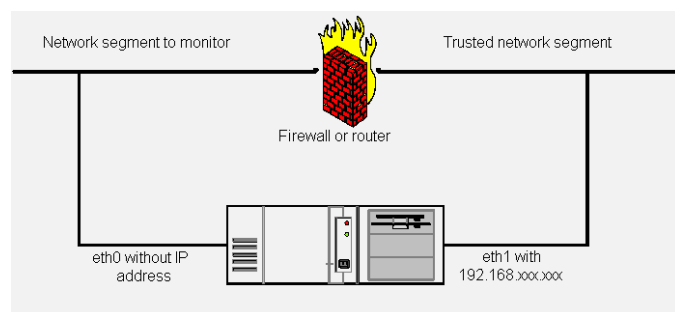
⁵² [http:// www.wikipedia.org](http://www.wikipedia.org)



IDS Deployment Problem 4: IDS Can Be Attacked by Intruders

IDS sensors need to be hardened to eliminate OS vulnerabilities

Employ “stealth” IP addressing on network interface cards (NICs)



Demo: Stealth IP

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3.6.4 IDS Deployment Problem 4

Another very real deployment problem is having intruders attack and disable the IDS through the exposed network connection. If the IDS can be successfully compromised by the intruder, his chances of being detected are greatly reduced. Traditionally, administrators have sought to solve this problem by hardening the host computer used as the IDS. While hardening the host should definitely be your first line of defense, another technique administrators use is to create a “stealth” interface as the network connection on the exposed network segment. All of the methods described below leave the IDS open to the remote but real possibility of layer two attacks. The only way around this is to either buy a professional network tap device or use a “receive only” cable.

Solution: Stealth Addressing on Linux/UNIX Systems

Edit the `ifcfg-eth0` file (for `eth1` it is `ifcfg-eth1`, for `eth2` it is `ifcfg-eth2`, and so on) so that the values for the broadcast, ipaddr, netmask, and network variables are all blank. (Note that `remote_ipaddr` is blank by default.) An example `ifcfg-eth0` file for Red Hat Linux would look similar to this:

```
BOOTPROTO='static'
REMOTE_IPADDR=''
STARTMODE='onboot'
UNIQUE='_+Pw.IQxIdIhhuH7'
WIRELESS='no'
BROADCAST=
IPADDR=
```

```
NETMASK=  
NETWORK=
```

When you reboot using “stealth” IP addressing in Linux, the OS will report it as an error. You can safely ignore the error message.

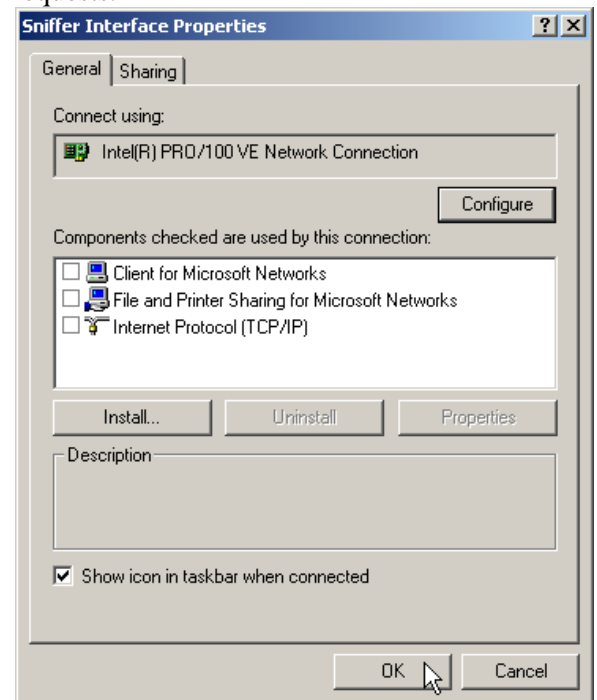
Solution: Stealth Addressing on Windows Systems

There are two choices when giving a Windows machine a “stealth” interface. The first option is certainly easier than the second, but you may have to try them both out to see which one works better in your environment.

Option 1: Unbind TCP/IP from the interface.

This is the preferred method, because it unbinds the TCP/IP stack from the interface. This means that the card will never reply to any TCP or IP requests.

1. Open the network connections folder
2. Right-click on the network interface you wish to create as a “stealth” interface, and click Properties.
3. Uncheck the Internet Protocol (TCP/IP) checkbox.



Option 2: Give the interface a 0.0.0.0 IP address.

You must edit the system registry to use 0.0.0.0 as a static IP address on the designated network interface instead of using the default IP address, e.g., 169.254.xxx.xxx. In reality, the default IP address of 169.254.xxx.xxx can be used as a stealth IP address since it is unlikely you will be routing this address on your network.

Open a command prompt window and issue the following command in the `c:\eaglex\snort\bin` directory:

```
snort -W
```

This will help you identify the interface you will be using for Snort if you have more than one network interface in the host computer.

To edit the Windows registry, run regedit. In the left panel of the Registry Editor window, select the following folder:

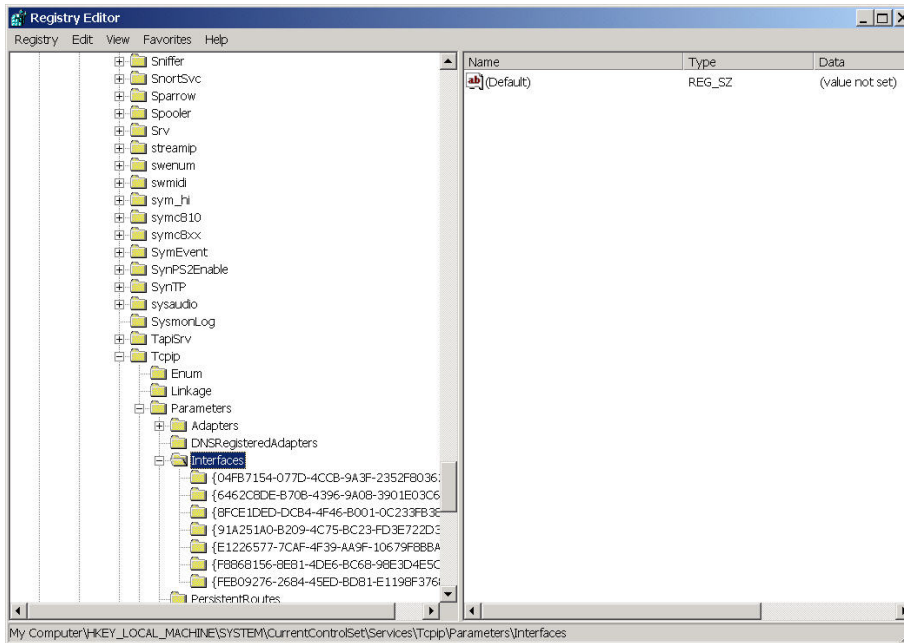


Figure 57: Registry Editor

1. From the Edit menu, select New > DWORD value.
2. Enter the name `IPAutoconfigurationEnabled` and press enter. Right click and select modify. Type 0 and press Enter.
3. Double click on the key `EnableDHCP` and set the value to 0.
4. Double click on the key `IPAddress` and set the value to the following:
`30 00 00 00 30 00 2E 00 30 00 2E 00 30 00 00 00 00 00`
5. Click OK. Exit the registry editor and reboot the PC.

Stealth IP addressing works on both types of systems because IDSs are passive devices and will continue to receive packets (because of the use of the libpcap/winpcap packet capture library) even with a blank or zeroed IP address, or a non-existent IP stack. Stealth IP addressing is a best practice for anyone who is running an IDS on a network.



Summary

IDS should be placed on all network segments you need to monitor and on critical hosts.

IDS signature files have to be updated (like A-V definitions) in order to recognize new types of threats

For optimum performance, rules files need to be configured to only monitor threats you are likely to encounter.

IDS should be hardened to attack (employ stealth addressing).

3.7 Summary



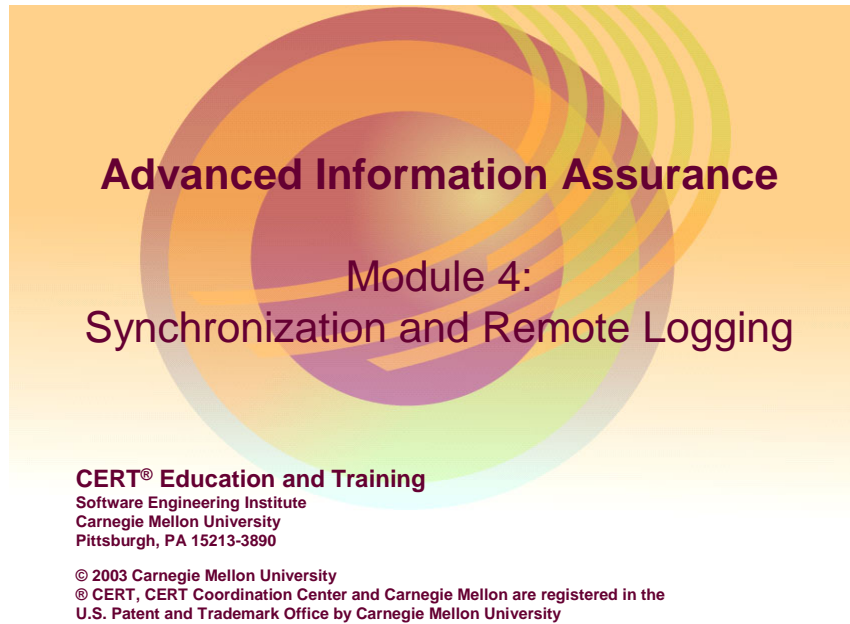
Review Questions

1. What type of IDS is Snort?
2. Name 3 IDS deployment problems. How do you overcome these deployment problems?
3. What is “stealth” deployment of an IDS? How is it done on a Linux host? On a Windows host?
4. Why is “stealth” IDS deployment important?
5. Why do you need to configure Snort rules (signature files)?

3.8 Review Questions

1. What type of IDS is Snort?
2. Name three IDS deployment problems. How do you overcome them?
3. What is “stealth” deployment of an IDS? How is it done on a Linux host? On a windows host?
4. Why is stealth IDS deployment important?
5. Why do you need to configure Snort rules (signature files)?

4 Synchronization and Remote Logging



This module provides students with applied knowledge in developing and implementing a remote syslog server, network time synchronization, basic network monitoring, and fundamental Internet and intranet forensic techniques (i.e., tracking and analysis).



Instructional Objectives

Describe a host-based syslog client, syslog server, and implementation strategies.

Implement the syslog protocol in a network environment.

Describe practical problems and solutions associated with administering a remote syslog server.

Describe network time synchronization.

Describe basic network monitoring and forensic techniques: analysis of intrusions and inappropriate access.

4.1 Instructional Objectives

Students will be able to do all of the above upon completion of this module.

The goal of Module 4 is not to provide abstract information, but rather to instill real-world skills and techniques.

Overview

Local- and remote-based logging

Remote syslog configuration strategies and techniques

Encryption of sensitive network syslog traffic

Network time synchronization

Deployment and management of syslog services

Network monitoring and basic forensic techniques

Analysis of log files

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Module 4: Network Monitoring and Forensics– Slide 3

4.2 Overview

This module will cover the topics outlined above.



Computer Forensics

Computer forensics is the **identification and extraction of stored or recorded digital/electronic evidence** (from the Latin root “forensis,” relating to the forum/legal business).

What it is...

Part of a process that provides depth and proof to a known event

A design to provide missing parts, not the complete picture

A dynamic process that is different from situation to situation.

What it **is not**...

Not a complete picture

Not a place to start and solely rely on

Not a template process that can be transferred from situation to situation

4.3 Computer Forensics

The term “computer forensics” has become an industry buzzword. Like many such terms, the popular understanding is a misinterpretation of its true meaning. Fundamentally, if you need to rely on forensics to provide an answer, something very wrong has happened. More importantly, the event was most likely the result of poor planning and design. Forensics are not security tools, but methods and processes used to augment security when breaches occur. Forensics primarily depends on the idea that someone or something has left behind evidence. A more technical definition of computer forensics is the identification and extraction of stored or recorded digital/electronic evidence [Vacca 02]. The root of the word “forensic” originates from the Latin word *forensis*, which refers to public proceedings before the forum (court).⁵³ Computer forensics refers to the identification and extraction of stored or recorded digital/electronic evidence in a manner that can be reproduced before the legal system (the courts).

Computer forensics are not just about locating erased data from a hard drive of a computer or recovering data from a log file. Forensics are meticulously documented and recorded processes that are both repeatable and verifiable. Forensics occur in a controlled environment, not ad hoc at the crime scene. Forensics are done with well known, tested, documented, and available tools; not with custom written scripts or open source tools that are untested or undocumented.

Forensics do not and cannot replace a well developed defense in depth strategy. Strictly speaking, forensics are not part of a defense strategy at all, but analysis tools used to help piece together events—security breaches, intrusions, exceeded authority—after they have

⁵³ http://www.askoxford.com/concise_oed/forensic

occurred. Further, forensics do so in a manner that is recorded, preserved, and repeatable, which makes them a valuable additional resource in the area of incident response.

Forensics are not very good stand-alone tools. They are much better suited for augmenting other information gathering assets. Let's look at an example of how forensics, along with security event logs, provide a more complete picture than either could alone. In this scenario, an administrator learns of an event but has no means of discovering what has happened at the host level. This is a perfect application for a forensic examination of the host user's system.

As a network administrator, you notice that one of your users has spoofed a media access control (MAC) address. (This could mean several things, but all of them indicate that the user is up to no good.) You have learned about the spoofed address from the arpwatch logs which indicated the change in IP/MAC pairing. But exactly what this user is doing is unknown.

The first thing the examiner does is enter the hard drive into evidence, establishing a controlled chain of custody from the time it leaves the employee's presence. Next, the examiner will remove the hard drive and make an exact copy of the drive using a well known and tested product such as Encase. The original drive will be returned to evidence where it will remain. The exact copy is now copied a second time, and this second copy is used for the examination. Now with the aid of your information about MAC spoofing, the examiner has a place to start and an idea of what to look for. After four days of testing and examination, the examiner reports that he has found a deleted copy of Cain,⁵⁴ a flat file containing MAC tables, usernames, passwords, and partial screen shots of HTTPS log-on Web pages.

You, the administrator, now examine this information and confirm that the MAC tables and usernames are indeed those of your network. You notify all the users of the network that their passwords may have been compromised. Based on the information recovered—the discovery of the partial screen shots of the HTTPS log on pages—it is likely that the user suspect attempted a “man in the middle” attack.

⁵⁴ www.oxid.it



Logging - 1

It is important to know what is happening on your network:

- **Connected Devices:** *User Workstations, Servers, Switches, Routers, etc.*
- **Production Services Running:** *Web, Mail, DNS, Print/File, etc.*
- **Security Services Running:** *IDS, SIM, Firewall, Sniffer, etc.*

4.4 Logging

Most computer network devices and the services running on those devices have been designed to produce messages about operational and security events. These messages can be quite valuable to administrators who know which messages to review and how to interpret them.

Collecting data generated by system, network, application, and user activities is essential for analyzing the security of your information assets and detecting signs of suspicious and unexpected behavior. Log files contain information about past activities. You should identify the logging mechanisms and types of logs (system, file access, process, network, application-specific, etc.) available for each asset and the data recorded within each log.

Logging produces information assets that describe, to varying degrees of completeness, the history of activities on a computing system or network device. Logging does not prevent an intrusion per se, but it does provide information that can help administrators recognize the signs of an intrusion. However, administrators can only recognize these signs if they are able to disseminate, extrapolate, and interpret the correct pieces of raw data.

Why Logging Is Important

Approaches to detecting signs of suspicious or unexpected behavior are often based on identifying differences between your current operational state and a previously captured and trusted expected state [CERT 03a].

You need to know where each asset is located and what information you expect to find in each location, and you need to be able to verify the correct or expected state of every asset. Without this information, you cannot adequately determine if anything has been added, deleted, modified, lost, or stolen. You may also be unable to rebuild a critical component that has been compromised without up-to-date, available, trusted characterizations.

In the following sections, we will detail the key tasks involved in logging data:

1. Identify the data to be captured using logging mechanisms. Determine what data is most useful to collect.
2. For all data categories, capture alerts and any reported errors.
3. Determine whether the logging mechanisms provided with your systems sufficiently capture the required information.
4. Review the logs.
5. Store and secure logged data.

We will also review the additional tasks inherent in remote logging:

1. Decide how actively to monitor the various kinds of logged data.
2. Protect logs to ensure that they are reliable.
3. Document a management plan for handling log files.
4. Protect data collection mechanisms and their outputs to ensure that they are reliable.
5. Review outputs regularly to understand what is expected and what is abnormal.
6. Take into account special data collection and handling procedures required to preserve data as evidence.
7. Consider policy issues.

4.4.1 Identify the Data to Be Captured Using Logging Mechanisms; Determine What Data Is Most Useful to Collect

You need to balance the importance of recording system, network, and user activities with the resources available to store, process, review, and secure them. These are some of the questions that can help you determine the usefulness of collected data:

- What is the priority of this asset (hardware, software, information)? How important is it to collect data related to this asset? How important is it to characterize this asset?
- What is the system's sole or primary purpose? For example, if a host is acting as a Web server, you want to capture Web logs.

- How many users are assigned to the system and how important is it for you to know who is logged on? This helps you decide how much login/logout information to capture.
- How important is it to be able to use your logs and other data to recover a compromised system? This helps you set the priority for capturing information such as data and file transaction logs.
- What are the range of services that can be performed on this system? Process accounting information is useful to detect unauthorized services and intruder actions.
- What is your organization's ability and capacity to process and analyze all collected data to obtain useful information when it is needed?

Table 5 shows data categories and possible types of data to collect, not only by logging but also by other methods such as monitoring, integrity checking, and vulnerability scanning. Use it as a guide to the types of information to log (although not all systems are able to log every type in the table). Tailor logging selections to meet your site's specific policies and security requirements. For each type of information you intend to log, identify the following:

- mechanisms used for logging
- locations where the logging is performed
- locations where the log files are stored

Later in this module, we will cover more detailed guidelines regarding what data to collect via logging on a particular host.

Table 5: Data Categories and Types of Data to Collect

Data Category	Types of data to collect
Network performance	<ul style="list-style-type: none"> • total traffic load in and out over time (packet, byte, and connection counts) and by event (such as new product or service release) • traffic load (percentage of packets, bytes, connections) in and out over time sorted by protocol, source address, destination address, other packet header data • error counts on all network interfaces
Other network data	<ul style="list-style-type: none"> • service initiation requests • name of the user/host requesting the service • network traffic (packet headers) • successful connections and connection attempts (protocol, port, source, destination, time) • connection duration • connection flow (sequence of packets from initiation to termination) • states associated with network interfaces (up, down) • network sockets currently open • whether or not network interface card is in promiscuous mode • network probes and scans • results of administrator probes
System performance	<ul style="list-style-type: none"> • total resource use over time (CPU, memory [used, free], disk [used, free]) • status and errors reported by systems and hardware devices • changes in system status, including shutdowns and restarts • file system status (where mounted, free space by partition, open files, biggest file) over time and at specific times • file system warnings (low freespace, too many open files, file exceeding allocated size) • disk counters (input/output, queue lengths) over time and at specific times • hardware availability (modems, network interface cards, memory)
Other system data	<ul style="list-style-type: none"> • actions requiring special privileges • successful and failed logins • modem activities • presence of new services and devices • configuration of resources and devices
Process performance	<ul style="list-style-type: none"> • amount of resources used (CPU, memory, disk, time) by specific processes over time; top “x” resource-consuming processes • system and user processes and services executing at any given time
Other process data	<ul style="list-style-type: none"> • user executing the process • process start-up time, arguments, file names • process exit status, time, duration, resources consumed

	<ul style="list-style-type: none"> • the means by which each process is normally initiated (administrator, other users, other programs or processes), with what authorization and privileges • devices used by specific processes • files currently open by specific processes
Files and directories	<ul style="list-style-type: none"> • list of files, directories, attributes • cryptographic checksums for all files and directories • accesses (open, create, modify, execute, delete), time, date • changes to sizes, contents, protections, types, locations • changes to access control lists on system tools • additions and deletions of files and directories • results of virus scanners
Users	<ul style="list-style-type: none"> • login/logout information (location, time): successful attempts, failed attempts, attempted logins to privileged accounts • login/logout information on remote access servers that appears in modem logs • changes in user identity • changes in authentication status, such as enabling privileges • failed attempts to access restricted information (such as password files) • keystroke monitoring logs • violations of user quotas
Applications	<ul style="list-style-type: none"> • applications- and services-specific information such as network traffic (packet content), mail logs, FTP logs, Web server logs, modem logs, firewall logs, SNMP logs, DNS logs, intrusion detection system logs, database management system logs. • Services specific information could be for <ul style="list-style-type: none"> – FTP requests: files transferred and connection statistics – Web requests: pages accessed, credentials of the requestor, connection statistics, user requests over time, which pages are most requested, and who is requesting them – mail requests: sender, receiver, size, and tracing information; for a mail server, number of messages over time, number of queued messages – DNS requests: questions, answers, and zone transfers – a file system server: file transfers over time – a database server: transactions over time
Log files	<ul style="list-style-type: none"> • results of scanning, filtering, and reducing log file contents • checks for log file consistency (increasing file size over time, use of consecutive, increasing time stamps with no gaps)
Vulnerabilities	<ul style="list-style-type: none"> • results of vulnerability scanners (presence of known vulnerabilities) • vulnerability patch logging

Turn off password logging. If possible, do not log passwords, even incorrect ones. Logging correct passwords creates an enormous potential vulnerability if a non-authorized user or intruder accesses log files. Recording incorrect passwords is also risky as they often differ from valid passwords by only a single character or transposition. Turning off password logging may require resetting a system default. If you cannot turn off password logging, you need to exercise special care in protecting access to log files that contain this information. However, you may want to log data about password use, such as the number of failed attempts and accesses to specific accounts.

4.4.2 For All Data Categories, Capture Alerts and Any Reported Errors

Log files may be the only record of suspicious behavior. Mechanisms that record this information can also initiate alert mechanisms. Failure to enable these mechanisms will greatly weaken or eliminate your ability to detect intrusion attempts and determine whether or not they succeeded. Similar problems can result from not having the necessary procedures and mechanisms in place to process and analyze your log files. You may need your logs files to

- alert you to suspicious activity that requires further investigation
- determine the extent of an intruder's activity
- help you recover your systems
- provide information required for legal proceedings

4.4.3 Determine Whether the Logging Mechanisms Provided with Your Systems Sufficiently Capture the Required Information

Identify the logging mechanisms available for the systems at your site. Determine what types of information each logging mechanism can capture. There may be differences in the log file contents provided by different vendors, even for similar types of systems.

Determine how each logging mechanism stores data—how the log files are named and where they are located. The names of these log files can differ even among versions of the same operating system delivered by a single vendor, so it is important that you verify this each time you upgrade your systems.



Logging - 2

It is important to know what is happening on your network.

Drawbacks of local logging:

- **Overabundance of logs:** *No time to review all logs, differentiating critical from non-critical, log files management*
- **Vulnerability of log files:** *Intruder can easily modify or delete local log files, logs unavailable if machine offline*
- **Multiple log locations:** *Only able to review a single host's logged activity at a time*

4.4.4 Review the Logs

It is possible that the logging and monitoring mechanisms provided with your systems may not produce all of the information necessary to detect signs of an intrusion in a timely manner. If adequate information is provided, the volume of data may be so overwhelming that automated analysis is required to reduce it to a manageable subset that you can examine it for signs of intrusive activity. In either case, you will need to add tools to your systems to adequately detect signs of suspicious or unexpected behavior that require further analysis.

4.4.5 Store and Secure Logged Data

It doesn't take long to see how saving every log to a file will rapidly eat up system storage space and administrators' time. In order for logging to be effective, there must be sufficient storage space and someone with the time and ability to review important logs for signs of abnormal system behavior. It is virtually impossible for an individual to review every log produced by a production device. The person with this responsibility must be able to identify the log files that are important enough to warrant review and be capable of interpreting the significant messages in relation to other seemingly unrelated messages. Although there is a request for comments⁵⁵ (RFC) that provides guidelines on how logs should be structured (syslog), logs still vary greatly, even from the same vendor. The administrator must be familiar with the log messages from most, if not all, of the devices and services running on the network.

⁵⁵ Syslog RFC 3164

Log files stored locally are at risk of deletion or modification by an intruder or system event, such as a hard disk crash.

Logging produces information which should be secured through all available access control devices (ACLs and encryption) and in all of the states where it resides (processing, transmission, and storage). When you are thinking about access control devices, add the notion of a dedicated centralized log server (or log host). This server, located in a protected area on your network, contains all of the log information from all machines in your system. It is a highly secured machine, including physical security against unwanted access through its console and other hardware communication ports. By consolidating all logs from all computers in one place, the administrator can more easily track the sum total of an intruder's activities throughout the entire network.

This centralized log server/log host should have sufficient disk space to hold all of the log information produced by computer systems throughout your network. It is unlikely that the cost of central logging would constrain anyone's ability to perform this task—for \$1,500 or less you can build a centralized log server/log host using Linux running on an Intel-based processor with 40GB or more of disk space. These days, disk space is inexpensive and the value of having all of the logs available for review in one location far outweighs the capital costs of the technology needed to support this activity.

UNIX/Linux

Unfortunately, not all applications can forward their log information to another computer system. For example, on Linux- or UNIX-based systems, process accounting information, which shows the log of processes run and other resource consumption information, is only available in a local file on the system where it is produced. Linux/UNIX-based machines come with a network-capable log collecting service called syslogd. If a system is running syslogd, which is installed by default, then that information would need to be moved or copied onto the network centralized log server/log host to achieve the “one-stop-shopping” log consolidation goal discussed here.

Syslog uses connectionless UDP that can support neither strong authentication nor an encrypted data channel to securely transmit log data. There are syslog replacements, most notably syslog-ng,⁵⁶ that address these issues. It supports the ability to send log messages via TCP, which in turn allows the use of SSH or SSL/TLS encryption. Syslog-ng also supports using local system files as the source from which logs are sent to the remote log server (or loghost).

⁵⁶ <http://www.balabit.hu/en/downloads/syslog-ng>

Windows

Windows-based machines are not syslog compatible, but there are packages that can copy information from the Windows Event Log into a syslog format. One such application is NTsyslog.⁵⁷ NTsyslog is a freeware service that can access the Windows Event Log and manipulate those logs in a way similar to the syslog protocol. This includes saving the logs to a file, forwarding them to a remote log server, and forwarding them to other hosts, as well as several other functions. To complement NTsyslog, Kiwi⁵⁸ offers a freeware limited functionality syslog daemon and service manager product for Windows environments. It works as a repository for all syslog log messages from hosts on the network. The client hosts on the network direct their remote logs to the log server host where the Kiwi Syslog Daemon exists. It then filters the messages that it receives and performs actions on those consolidated log messages, such as displaying them in a graphical display, saving them to log files, and forwarding them on to other hosts.

Other Network Devices and Apps

Most other devices that are connected to the network and some software installed on those devices also have the ability to send logs to a remote log server. Devices include servers, switches, routers, printers, and others. It is beyond the scope of this document to attempt to describe the configuration of each of these devices to enable remote syslogging. The next section will provide the fundamentals of remote logging to help students understand the specific configurations of all enabled devices on their networks. Software includes security apps like host-based FW, IDS, and SIM as well as many production apps.

⁵⁷ <http://sabernet.home.comcast.net/software/ntsyslog.html>

⁵⁸ <http://www.kiwisyslog.com/>

Remote Logging: Syslog Security and File Management

- Only critical messages sent to remote server/all logs locally
- Central syslog server in highly protected area of network
- Local compromise does not affect remote log files
- Cross-check multiple systems to investigate incidents
- Dedicated log server has more disk space
- Documented file management plan

4.5 Remote Logging

4.5.1 Decide How Actively to Monitor the Various Kinds of Logged Data

Previous modules have discussed making decisions about what needs to be logged. All decisions about what to log should be based upon documented policies and procedures. These policies and procedures should reflect the mission of the organization, the purpose of the devices and their running services, and the value placed on their continuous operation.

The same considerations should inform decisions about what should be logged locally and what should be logged on the remote log server. For the most part, any events that could potentially cause harm, downtime, or undesired effects to important network devices or the network itself will need to be logged remotely. Messages regarding the operations of secondary, non-critical host services may be logged locally, as their inclusion could be a detriment to a central logging effort.

For the subset of messages that will be logged remotely, you must decide which messages should be monitored on a real-time or regular basis, which messages should be sent to administrators via email or pager, and which ones can simply be saved to flat file or database for later review.

The syslog daemon (syslogd) is designed to provide these very functions. Syslogd is the standard service for UNIX and Linux systems. The system log daemon (syslogd) and the kernel log daemon (klogd) are automatically installed on UNIX- or Linux-based systems. They are configured to start running on startup according to the syslog protocol. The

configuration file, `syslog.conf`, is also set up with default settings to log certain messages to the console, users, and/or log files. In Linux, logs are sent to various files in the `/var/log` directory, but the files can be created in other directories, preferably ones owned by “root.” Syslogd is designed to support both local and remote logging.

Syslogd will listen on a UNIX domain socket as well as on the standard syslog port 514 UDP.⁵⁹ The UNIX domain socket connection listens for locally generated logs. The UDP 514 connection tries to connect to the remote log server. Syslogd will make 10 attempts to resolve the log server’s hostname. If the domain name server starts up after syslogd’s tenth attempt to resolve the remote log server’s hostname, the connection will fail out. However, the hostname can be added to `/etc/hosts` to correct this infrequently occurring problem.

4.5.2 Protect Logs to Ensure That They Are Reliable⁶⁰

To protect sensitive information, ensure that log files are protected from being accessed or modified by unauthorized users. Confirm that only authorized users can access utilities that reconfigure logging mechanisms; turn utilities on and off; or write to, modify, and read log data.

It is important to collect and archive log files in a location that is only accessible by administrators. This is to ensure that intruders cannot modify the logs to remove or alter signs of an intrusion or add erroneous information. Consider the following methods to ensure that log files are not modified:

- Send log data to a file on a separate host that is dedicated solely to log collecting. The log host should reside in a physically secure location that is not easily accessible from the network. For example, capturing log data using a computer via a dedicated serial line provides a way of storing the log files more securely than if they were written on the logging host’s disks.
- Use encrypted transmission channels to send log data from client hosts to the log host.
- Send log data to a “write once, read many” (WORM) device (such as CD-ROM or a specially configured tape drive) or to a write-only device (such as a printer) to eliminate the possibility of the data being modified once it is written.
- If your systems permit, set selected log file attributes that enable only new information to be appended to the log files (i.e., new records can be added, those already recorded cannot be modified).
- Encrypt log files, particularly those that contain sensitive data or those being transmitted across a network.

⁵⁹ <http://www.die.net/doc/linux/man/man8/syslogd.8.html>

⁶⁰ <http://www.cert.org/security-improvement/practices/p092.html>

Logging directly to disk on the local host is easiest to configure and allows instant access to file records for analysis, but it is also the least secure. Collecting log files on a write-once device requires slightly more effort to configure but is more secure.

Printing the logging results is useful when you require permanent and immediate log files, but this may be inconvenient as printed logs can be difficult to search, require manual analysis, and potentially require a large physical storage space.

When the host generating the log data is different from the host recording it, you must secure the path between them. For environments where short distances separate the generating host from the recording host, you can connect them with single point-to-point cable(s). For environments where this approach is not practical, minimize the number of network connections between the client and the server or encrypt sensitive log data as it is generated.

To protect the log files on your log host, place the host on a separate, secure subnet that is protected by a firewall. Set access permissions for log files so that they are read-only files and may only be read from the log host console or a secure remote console.

You need to prepare systems that perform logging to ensure that they do not stop functioning in the event of a logging denial-of-service attack. For UNIX systems, an intruder could launch an attack that fills up the syslog files—when the logging partition is full, logging will cease. For NT systems, an intruder could overwrite the oldest log file entries after filling all available storage. To prepare a system so that it will continue to function, create separate file partitions for different log information and filter network messages to decrease the likelihood of such attacks.

In addition, some systems provide the capability to shut down (or prohibit anyone but the system administrator to log in) and produce a warning when the log files are full. However, this is not normally the default configuration so it must be explicitly specified.

4.5.3 Document a Management Plan for Handling Log Files

Create a documented and approved management plan for handling log files. It is important to address and explain a few important issues in a formal document. This document should be prepared with the input and buy-in of the concerned parties and it should then be approved by the CIO or similar executive decision makers. It should be created in accordance with the overall policies, procedures, and mission of the organization and the network administration group. This will result in file management procedures that persist over time, creating a consistent set of archived log files and a predetermined process for dealing with new log files. It also makes researching past log files much easier. The management plan should document issues relating to the practices outlined in the following paragraphs.

Handling the total volume of logged information. Because it is difficult to anticipate which logs will be critical in the event of an intrusion, we recommend that you log as much as possible for your systems and networks. Although log files can very quickly consume a great deal of storage, it is also true that storage is relatively inexpensive. Based on your log collection and storage approach, you may want to compress log files and make them accessible online to make them easier to review and to conserve space.

Rotating log files. This activity consists of

- making a copy of the active (online) log files at regular intervals (ranging from daily to weekly)
- renaming the files so information contained in the file is not further augmented
- resetting file contents
- verifying that logging still works

Rotating log files allows you to limit the volume of log data you have to examine at any given time. It also allows you to keep log files open for a limited duration so that damage is bounded if an active log file is compromised. In this way, you create a collection of log files that contain well-defined time intervals of recorded data.

You can then consolidate logs from different systems by matching time intervals. This will help you gain a network-wide perspective on activities. To perform this consolidation, you will likely need to merge log files from different systems into a central log file. To avoid having to adjust the timestamps used in each, use a master clock system such as Network Time Protocol (NTP) or another time synchronization protocol system. Make sure to take into account different time zones and formats for recorded time. This topic will be covered in more detail in Section 4.6, Computer Time Synchronization.

Backing up and archiving log files. Move your log files to permanent storage or capture them as part of your regular backup procedure. This will allow you to retrieve them later if the need arises. Document the method you use to access archived log files. Before you execute any automated tools that truncate and reset the log files, create backups so that no data is lost.

Encrypting log files. Because log data is being recorded, we recommend encrypting log files that contain sensitive data. Protect the encryption software and place a copy of your encryption keys on a floppy disk or WORM CD-ROM in a secure location such as a safe or safety deposit box. If the keys are lost, the log files cannot be used. If possible, use public key encryption.

The logs can be encrypted using the public key (which can be safely stored online) and the corresponding private key (stored offline) can then be used to decrypt the logs.

Ensuring that you have the system and personnel resources necessary to analyze logs on a regular basis (at least daily in most cases) and on demand (such as when alert events occur).

Disposing of log files. Ensure that all media containing log file data are securely disposed of (e.g., shredding hardcopy output, sanitizing disks, destroying CDs).

4.5.4 Protect Data Collection Mechanisms and Their Outputs to Ensure That They Are Reliable

Make sure you obtain log collection and analysis tools from a reliable source and verify the integrity of the software through digital signatures, cryptographic checksums, or by using trusted copies from secure media. Intruders have been known to modify tools installed by authorized administrators so that the tools, when used, do not identify the presence of the intruder.

Once you have verified the software, you need to configure it for use at your site. The installation should be performed on a secure system to eliminate the possibility of the tool being tampered with before you have had a chance to deploy it. You should make a cryptographic checksum of these tools. Using this information, you can then verify that your original configuration has not been compromised. You need to protect these tools by ensuring that they have the appropriate access control lists set to allow use and modification only by authorized users. The reports produced by these tools also need to be protected so that only authorized users can use them.

4.5.5 Review Outputs Regularly to Understand What Is Expected and What Is Abnormal

Now you've built a remote logging infrastructure that consolidates all critical logs onto a single machine. On this machine, the connections are strongly authenticated and the data is encrypted against theft and unwanted viewing. What happens next?

Someone—the administrator—needs to look at the logs often enough to be able to detect abnormalities, some of which may be signs of intrusion. The review process can be automated through analysis and notification tools such as the Kiwi Syslog Daemon Service Manager. The challenge of this activity is to configure these tools to look for specific entries that are indicators of intrusion attempts or that represent abnormal behavior. What is abnormal behavior? It is anything that is unexpected—but “unexpected” is difficult to define when you don't know what “expected” is.

4.5.6 Take into Account Special Data Collection and Handling Procedures Required to Preserve Data as Evidence.

This is required in the event that an intrusion actually occurs and your organization decides to take legal action against the intruder. For more information, see the CERT Security

Improvement Module *Responding to Intrusions* [CERT 03b], specifically the practice “Collect and protect information associated with an intrusion.”⁶¹

4.5.7 Consider Policy Issues

Your organization's security policy for networked systems should do the following:

- require that you create a management plan for handling log files that documents what, when, where, and why to log as well as who is responsible for all aspects of the plan
- identify approved sources for acquiring tool software (Internet, shareware, purchased from vendor, etc.) and acceptable use practices related to tools

⁶¹ <http://www.cert.org/security-improvement/practices/p048.html>

Remote Logging: Syslog Alert and Message Configurations (Facilities and Severity)

Facility	Description	Severity	Description
kern	Produced by kernel messages	emerg	Any emergency condition
user	Default facility, used for any program	alert	Any condition that demand immediate attention
mail	Mail system	crit	Critical conditions like hardware problems
daemon	System/network daemons	err	Any errors
auth	Used by authorization systems (login)	warn	Any warnings
syslog	Message generate internally by syslog	notice	Conditions that may require attention
lpr	Printing system	info	Informational messages
news	Reserved for the news system	debug	Normally used for debugging
uucp	Reserved for the uucp system		
cron	Used for the cron and at systems		
mark	Internally used for time stamps		

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4.5.8 Syslog Alert and Message Configurations

Below is an excerpt from the syslog RFC 3164.⁶² Although syslog has been around for a long time, it was first documented in an RFC in August of 2001. The RFC provides a wealth of information and insight into what syslog does and how it does it, especially in dealing with facility and severity level settings. It is for this reason that we have provided some of the more relevant sections of the RFC in this text.

Section 4.1, Syslog Message Parts, describes the syslog packet. Sections 4.1.1 – 4.1.3 describe the three components of the syslog message, including the facility categories and the severity levels. This technical overview will prove useful because—as you will learn—syslog only transports what the specific operation or application sends, so there will always be variations in received syslog messages from across a network. Understanding what syslog is doing will help you understand the message itself.

Introduction

In its most simplistic terms, the syslog protocol provides a transport to allow a machine to send event notification messages across IP networks to event message collectors - also known as syslog servers. Since each process, application and operating system was written somewhat independently, there is little uniformity to the content of syslog messages. For this reason, no assumption is made upon the formatting or contents of the messages. The protocol is simply designed to transport these event messages. In all cases, there is one device that originates the message. The syslog process on that machine may send the message to a collector. No acknowledgement of the receipt is made.

⁶² <http://www.ietf.org/rfc/rfc3164.txt> (See copyright statement at the end of excerpt.)

One of the fundamental tenets of the syslog protocol and process is its simplicity. No stringent coordination is required between the transmitters and the receivers. Indeed, the transmission of syslog messages may be started on a device without a receiver being configured, or even actually physically present. Conversely, many devices will most likely be able to receive messages without explicit configuration or definitions. This simplicity has greatly aided the acceptance and deployment of syslog.

4.1 Syslog Message Parts

The full format of a syslog message seen on the wire has three discernable parts. The first part is called the PRI, the second part is the HEADER, and the third part is the MSG. The total length of the packet MUST be 1024 bytes or less. There is no minimum length of the syslog message although sending a syslog packet with no contents is worthless and SHOULD NOT be transmitted.

4.1.1 PRI Part

The PRI part MUST have three, four, or five characters and will be bound with angle brackets as the first and last characters. The PRI part starts with a leading "<" ('less-than' character), followed by a number, which is followed by a ">" ('greater-than' character). The number contained within these angle brackets is known as the Priority value and represents both the Facility and Severity as described below.

The Facilities and Severities of the messages are numerically coded with decimal values. Some of the operating system daemons and processes have been assigned Facility values. Processes and daemons that have not been explicitly assigned a Facility may use any of the "local use" facilities or they may use the "user-level" Facility. Those Facilities that have been designated are shown in the following table along with their numerical code values.

Table 1. Syslog Message Facilities

Numerical Code	Facility Def
0	kernel messages
1	user-level messages
2	mail system
3	system daemons
4	security/authorization messages (note 1)
5	messages generated internally by syslogd
6	line printer subsystem
7	network news subsystem
8	UUCP subsystem
9	clock daemon (note 2)
10	security/authorization messages (note 1)
11	FTP daemon
12	NTP subsystem
13	log audit (note 1)
14	log alert (note 1)
15	clock daemon (note 2)
16	local use 0 (local0)
17	local use 1 (local1)
18	local use 2 (local2)
19	local use 3 (local3)
20	local use 4 (local4)
21	local use 5 (local5)
22	local use 6 (local6)
23	local use 7 (local7)

Note 1 - Various operating systems have been found to utilize Facilities 4, 10, 13 and 14 for security/authorization, audit, and alert messages which seem to be similar.

Note 2 - Various operating systems have been found to utilize both Facilities 9 and 15 for clock (cron/at) messages.

Each message Priority also has a decimal Severity level indicator. These are described in the following table with their numerical values.

Table 2. Syslog Message Severities

Numerical Code	Severity Def
0	Emergency: system is unusable
1	Alert: action must be taken immediately
2	Critical: critical conditions
3	Error: error conditions
4	Warning: warning conditions
5	Notice: normal but significant condition
6	Informational: informational messages
7	Debug: debug-level messages

The Priority value is calculated by first multiplying the Facility number by 8 and then adding the numerical value of the Severity.

For example, a kernel message (Facility=0) with a Severity of Emergency (Severity=0) would have a Priority value of 0. Also, a "local use 4" message (Facility=20) with a Severity of Notice (Severity=5) would have a Priority value of 165. In the PRI part of a syslog message, these values would be placed between the angle brackets as <0> and <165> respectively. The only time a value of "0" will follow the "<" is for the Priority val of "0". Otherwise, leading "0"s MUST NOT be used.

4.1.2 HEADER Part of a syslog Packet

The HEADER part contains a timestamp and an indication of the hostname or IP address of the device. The HEADER contains 2 fields called the TIMESTAMP and the HOSTNAME. The TIMESTAMP will immediately follow the trailing ">" from the PRI part and single space characters MUST follow each of the TIMESTAMP and HOSTNAME fields. HOSTNAME will contain the hostname, as it knows itself. If it does not have a hostname, then it will contain its own IP address. If a device has multiple IP addresses, it has usually been seen to use the IP address from which the message is transmitted. An alternative to this behavior has also been seen. In that case, a device may be configured to send all messages using a single source IP address regardless of the interface from which the message is sent. This will provide a single consistent HOSTNAME for all messages sent from a device.

The TIMESTAMP field is the local time and is in the format: "Mmm dd:hh:mm:ss" (without the quote marks) where: A single space character MUST follow the TIMESTAMP field.

The HOSTNAME field will contain only the hostname, the IPv4 address, or the IPv6 address of the originator of the message. The preferred value is the hostname. If the hostname is used, the HOSTNAME field MUST contain the hostname of the device as specified in STD 13 [4]. It should be noted that this MUST NOT contain any embedded spaces. The Domain Name MUST NOT be included in the HOSTNAME field. If the IPv4 address is used, it MUST be shown in dotted decimal notation as used in STD 13 [5]. If an IPv6 address is used, any valid representation used in RFC 2373 [6] MAY be used. A single space character MUST also follow the HOSTNAME field.

4.1.3 MSG Part of a syslog Packet

The MSG part will fill the remainder of the syslog packet. This will usually contain some additional information of the process that generated the message, and then the text of the message. There is no ending delimiter to this part. The MSG part of the syslog packet MUST contain visible (printing) characters

The MSG part has two fields known as the TAG field and the CONTENT field. The value in the TAG field will be the name of the program or process that generated the message. The CONTENT contains the details of the message. This has traditionally been a freeform message that gives some detailed information of the event. The TAG is a string of ABNF alphanumeric characters that MUST NOT exceed 32 characters. Any non-alphanumeric character will terminate the TAG field and will be assumed to be the starting character of the CONTENT field. Most commonly, the first character of the CONTENT field to signify the conclusion of the TAG field has been seen to be the left square bracket character ("["), a colon character (":"), or a space character. This is explained in more detail in Section 5.3.

4.2 Original syslog Packets Generated by a Device

There are no set requirements on the content of the syslog packet as it is originally sent from a device. It should be reiterated here that the payload of any IP packet destined to UDP port 514 MUST be considered to be a valid syslog message. It is, however, RECOMMENDED that the syslog packet have all parts described in Section 4.1-PRI, HEADER and MSG -as this enhances readability by the recipient and eliminates the need for a relay to modify the message.

4.3 Relayed syslog Packets

When a relay receives a packet, it will check for a valid PRI. If the first character is not a less-than sign, the relay MUST assume that the packet does not contain a valid PRI. If the 3rd, 4th, or 5th character isn't a right angle bracket character, the relay again MUST assume that the PRI was not included in the original message. If the relay does find a valid PRI part then it must check for a valid TIMESTAMP in the HEADER part. From these rules, there will be three general cases of received messages. Table 3 gives the general characteristics of these cases and lists the subsequent section of this document that describes the handling of that case.

Table 3. Cases of Received syslog Messages

Case	Section
Valid PRI and TIMESTAMP	4.3.1
Valid PRI but no TIMESTAMP or invalid TIMESTAMP	4.3.2
No PRI or unidentifiable PRI	4.3.3

4.3.1 Valid PRI and TIMESTAMP

If the relay does find a valid PRI and a valid TIMESTAMP, then it will check its internal configuration. Relays MUST be configured to forward syslog packets on the basis of their Priority value. If the relay finds that it is configured to forward the received packet, then it MUST do so without making any changes to the packet. To emphasize the point one more time, it is for this reason that it is RECOMMENDED that the syslog message originally transmitted adhere to the format described in Section 4.1.

It should be noted here that the message receiver does not need to validate the time in the TIMESTAMP field. The assumption may be made that a device whose date has not been correctly set will still have the ability to send valid syslog messages. Additionally, the relay does not need to validate that the value in the HOSTNAME field matches the hostname or IP of the device sending the message. A reason for this behavior may be found in Section 4.1.2.

4.3.2 Valid PRI but no TIMESTAMP or invalid TIMESTAMP

If a relay does not find a valid TIMESTAMP in a received syslog packet, then it MUST add a TIMESTAMP and a space character immediately after the closing angle bracket of the PRI part. It SHOULD additionally add a HOSTNAME and a space character after the TIMESTAMP. These fields are described here and detailed in Section 4.1.2. The remainder of the received packet MUST be treated as the CONTENT field of the MSG and appended. Since the relay would have no way to determine the originating process from the device that originated the message, the TAG value cannot be determined and will not be included.

The **TIMESTAMP** will be the current local time of the relay.

The **HOSTNAME** will be the name of the device, as it is known by the relay. If the name cannot be determined, the IP address of the device will be used.

If the relay adds a **TIMESTAMP**, or **TIMESTAMP** and **HOSTNAME**, after the **PRI** part, then it **MUST** check that the total length of the packet is still 1024 bytes or less. If the packet has been expanded beyond 1024 bytes, then the relay **MUST** truncate the packet to 1024 bytes. This may cause the loss of vital information from the end of the original packet. It is for this reason that it is **RECOMMENDED** that the **PRI** and **HEADER** parts of originally generated syslog packets contain the values and fields documented in Section 4.1.

4.3.3 No PRI or Unidentifiable PRI

If the relay receives a syslog message without a **PRI**, or with an unidentifiable **PRI**, then it **MUST** insert a **PRI** with a Priority value of 13 as well as a **TIMESTAMP** as described in Section 4.3.2. The relay **SHOULD** also insert a **HOSTNAME** as described in Section 4.3.2. The entire contents of the received packet will be treated as the **CONTENT** of the relayed **MSG** and appended. An example of an unidentifiable **PRI** would be "<00>", without the double quotes. It may be that these are the first 4 characters of the message. To continue this example, if a relay does receive a syslog message with the first 4 characters of "<00>", then it will consult its configuration. If it is configured to forward syslog messages with a Priority value of 13 to another relay or collector, then it **MUST** modify the packet as described above. The specifics of doing this, including the **RECOMMENDED** insertion of the **HOSTNAME**, are given below.

Originally received message

<00>...

Relayed message

<13>**TIMESTAMP** **HOSTNAME** <00>...

If the relay adds a **TIMESTAMP**, or **TIMESTAMP** and **HOSTNAME**, after the **PRI** part, then it **MUST** check that the total length of the packet is still 1024 bytes or less. If the packet has been expanded beyond 1024 bytes, then the relay **MUST** truncate the packet to 1024 bytes. This may cause the loss of vital information from the end of the original packet. It is for this reason that it is **RECOMMENDED** that the **PRI** and **HEADER** parts of originally generated syslog packets contain the values and fields documented in Section 4.1.

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Remote Logging: Linux/Unix Syslog “Client”

Default Syslog Config File

```
# Log all kernel messages to the console.
# Logging much else clutters up the screen.
#kern.* /dev/console

# Log anything (except mail) of level info or higher.
*.info;mail.none;authpriv.none;cron.none /var/log/messages

# The authpriv file has restricted access.
authpriv.* /var/log/secure

# Log all the mail messages in one place.
mail.* /var/log/maillog

# Log cron stuff
cron.* /var/log/cron

# Everybody gets emergency messages
*.emerg *

# Save news errors of level crit and higher in a special file.
uucp,news.crit /var/log/spooler

# Save boot messages also to boot.log
local7.* /var/log/boot.log

# Send all logs to the Remote Syslog Server
*.* @remoteSyslogServer
```

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Allows for logging locally, configuration changes needed to log remotely

Modify the default syslog.conf file to send logs to the remote log server Add “*.* @remoteLogServer” to the .conf file

Can change any of the Facilities and Severities in any line to modify which messages are logged to which destinations

Restart the syslog service so that the new configuration will be activated in the service

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4.5.9 Linux/UNIX Syslog Client

The only effort that needs to be made to effectively use syslog on Linux/UNIX systems is to open the `syslog.conf` file, located in the `/etc` directory, and edit the configuration settings according to the importance of the particular services that are running on that system. To get the syslog service to send messages to the remote syslog server, one simple line is added to the `syslog.conf` file. In Figure 58, all of the lines existed in the original default file except for the last two lines, which had to be added to the file to send syslog messages to the remote server. The only other thing of concern is to review the `/etc/services` file to make sure that it includes a line that contains `syslog 514/udp`.

In the `syslog.conf` file all empty lines are ignored, as are all lines that begin with a hash mark (#), which indicates user comments. The other lines all follow this format: `selector [space] action`. The selector field consists of a facility and a severity level separated by a period (.). Here is another way to view this:

facility.severity destination

This is the line that enables remote logging:

```
*.* @remoteSyslogServer
```

This means that logs of all facilities and all severities (basically all logs) are sent to the system that has the hostname “remoteSyslogServer.” The hostname could also be replaced by the system’s IP address, which is acceptable as long as the IP is statically, not dynamically, assigned.

The third line in the file, if the comment character (#) were removed, would allow all kernel-level messages of all severities to be displayed to the console. All the other lines have various combinations of facilities and severity levels sent to different log files in the /var/log directory. Note that several facilities can be listed, separated by commas, and the severity level that follows applies to all facilities in that list. Further, when a severity level is used, all severity levels from that level and higher are included. For example, `uucp,news.crit` will include log messages from uucp and news at severity levels “critical,” “alert,” and “emergency.”

The use of the level `uucp.none` would accept no log messages from the uucp facility. The use of the equality symbol (=) indicates that only that exact severity level is considered, rather than all levels at and above that level. The use of the exclamation point (!) indicates negation. For example, `[lpr.*;lpr.!=error]` would mean that all severity levels except the “error” level would be included for the lpr facility.

```
=====BEGIN=====
# Log all kernel messages to the console.
# Logging much else clutters up the screen.
#kern.*                                     /dev/console

# Log anything (except mail) of level info or higher.
# Don't log private authentication messages!
*.info;mail.none;authpriv.none;cron.none
    /var/log/messages

# The authpriv file has restricted access.
authpriv.*                                 /var/log/secure

# Log all the mail messages in one place.
mail.*                                     /var/log/maillog

# Log cron stuff
cron.*                                    /var/log/cron

# Everybody gets emergency messages
*.emerg                                   *

# Save news errors of level crit and higher in a special file.
uucp,news.crit                            /var/log/spooler

# Save boot messages also to boot.log
local7.*                                  /var/log/boot.log

# Send all logs to the Remote Syslog Server
*.*                                       @remoteSyslogServer
=====END=====
```

Figure 58: Example of a Syslog.conf File

When changes are made to the `syslog.conf` file, the `syslog` service must be stopped and restarted so that it can reload the file and operate according to the new settings. To restart the `syslog` service, enter the following shell command:

```
service syslog restart
```

Then, to verify that the service is running, enter `status` instead of `restart`, and it should produce a message that shows the `pid` of the running service.

`Syslog` manual pages contain a wealth of information on configuration, installation, and filtering. On most Linux/UNIX boxes the manual pages are available and can be accessed by simply typing `> man syslog` at the command line. Below we have copied sections of the manual that provide a deeper understanding of the syntax used in establishing filters (rules) using facilities and severity levels.

Excerpts from the Syslog Manual Pages⁶³

```
syslog.conf(5) - Linux man page
EXAMPLES
Here are some example, partially taken from a real existing site and
configuration. Hopefully they rub out all questions to the
configuration, if not, drop me (Joey) a line.
# Store critical stuff in critical
#
*.=crit;kern.none                /var/adm/critical
This will store all messages with the priority crit in the file
/var/adm/critical, except for any kernel message.
# Kernel messages are first, stored in the kernel
# file, critical messages and higher ones also go
# to another host and to the console
#
kern.*                          /var/adm/kernel
kern.crit                       @finlandia
kern.crit                       /dev/console
kern.info;kern.!err            /var/adm/kernel-info
The first rule direct any message that has the kernel facility to
the file /var/adm/kernel.
The second statement directs all kernel messages of the priority
crit and higher to the remote host finlandia. This is useful,
because if the host crashes and the disks get irreparable errors you
might not be able to read the stored messages. If they're on a
remote host, too, you still can try to find out the reason for the
crash.
The third rule directs these messages to the actual console, so the
person who works on the machine will get them, too.
The fourth line tells the syslogd to save all kernel messages that
come with priorities from info up to warning in the file
/var/adm/kernel-info. Everything from err and higher is excluded.
# The tcp wrapper logs with mail.info, we display
# all the connections on tty12
#
```

⁶³ <http://www.die.net/doc/linux/man/man5/syslog.conf.5.html>

```

mail.=info                                /dev/tty12
This directs all messages that uses mail.info (in source LOG_MAIL |
LOG_INFO) to /dev/tty12, the 12th console. For example the
tcpwrapper tcpd(8) uses this as its default.
# Store all mail concerning stuff in a file
#
mail.*;mail.!=info                        /var/adm/mail
This pattern matches all messages that come with the mail facility,
except for the info priority. These will be stored in the file
/var/adm/mail.
# Log all mail.info and news.info messages to info
#
mail,news.=info                           /var/adm/info
This will extract all messages that come either with mail.info or
with news.info and store them in the file /var/adm/info.
# Log info and notice messages to messages file
#
*.=info;*.=notice;\
    mail.none /var/log/messages
This lets the syslogd log all messages that come with either the
info or the notice facility into the file /var/log/messages, except
for all messages that use the mail facility.
# Log info messages to messages file
#
*.=info;\
    mail,news.none /var/log/messages
This statement causes the syslogd to log all messages that come with
the info priority to the file /var/log/messages. But any message
coming either with the mail or the news facility will not be stored.
# Emergency messages will be displayed using wall
#
*.=emerg *
This rule tells the syslogd to write all emergency messages to all
currently logged in users. This is the wall action.
# Messages of the priority alert will be directed
# to the operator
#
*.alert root,joe
This rule directs all messages with a priority of alert or higher to
the terminals of the operator, i.e. of the users ``root`` and
``joey`` if they're logged in.
*.* @finlandia
This rule would redirect all messages to a remote host called
finlandia. This is useful especially in a cluster of machines where
all syslog messages will be stored on only one machine.

```



Remote Logging: Syslog-ng (New Generation) vs. Syslogd

Must install and configure syslog-ng as after-market

Complex configuration file: syslog-ng.conf

Increased versatility of syslog-ng:

- Ability to better relay (forward) syslog messages
- Ability to send via TCP as well as UDP: increased security and reliability with connection-oriented protocol
- Ability to read the process accounting files on system
- Better message filtering

4.5.10 Syslog-ng Vs. Syslogd

Syslog-ng is the next generation of syslogd and addresses many of the weaknesses of syslogd. One of the biggest improvements is the use of TCP rather than UDP at the transport protocol. This not only allows for a reliable delivery but also an easy method of encryption if it is desired.

Also, syslog-ng offers much more granularity with message filtering, the ability to read from any file on a system, and a much more reliable relay function. However, these improvements come at a cost. Syslog-ng is much more difficult to set up and configure. It is not a standard feature on Linux/UNIX boxes, so it must be downloaded and installed. Also, another weakness is that there are few sources of documentation. Below are some good installation instructions we found on the O'Reilly Web site [O'Reilly 02]:

Installation Instructions

Type all the characters in bold format exactly as shown, with the exception of replacing “x.x.x” with actual version numbers:

1. Make sure that you are operating as root.
2. Download syslog-ng from <http://www.balabit.com/products/syslog-ng/upgrades.bbq> into `/usr/local`. Be sure to get the latest stable version.
3. Download the latest version of Libol from the same Web site into same directory.
4. **cd /usr/local**

5. **tar -zxvf libol-x.x.x.tar.gz**

Note: Libol must be opened, compiled, and installed before opening syslog-ng.

6. **cd libol-x.x.x**

7. **./configure && make && make install**

8. **cd ..**

9. **tar -zxvf syslog-ng-x.x.x.tar.gz**

10. **cd syslog-ng-x.x.x**

11. **./configure && make && make install**

CAUTION: The use of **./make** and **./make install** (steps 3 and 4 of O'Reilly's Syslog Ch.10, p. 15) did not work with RedHat Linux 8.0. This command did not find the make files.

12. **mkdir /usr/local/etc/syslog-ng**

13. **cp /usr/local/syslog-ng-x.x.x/contrib/syslog-ng.conf.RedHat
/usr/local/etc/syslog-ng/syslog-ng.conf**

Note: There is a space between ".RedHat" and "/usr/local/etc/syslog-ng/syslog-ng.conf."

14. **cp /usr/local/syslog-ng-x.x.x/contrib/init.d.RedHat-7.3
/etc/init.d/syslog-ng**

Note: There is a space between ".RedHat-7.3" and "/etc/init.d/syslog-ng."

15. **cd /etc/init.d**

16. **chkconfig --list | grep on | sort**

Note: You should not see syslog-ng

17. **chkconfig --add syslog-ng**

18. **chkconfig --list | grep on | sort**

Note: You should see syslog-ng turned on for rc 2, 3, 4, and 5.

19. **ls**

Note: Syslog-ng should be black.

20. **chmod +x syslog-ng**

21. **ls**

Note: Syslog-ng should be green (i.e., executable).

22. **service syslog-ng start**

Note: Should give the "OK."

23. **service syslog-ng status**

Note: Should be running with a pid.

24. **service syslog stop**

Note: You should shut down kernel and system loggers.

25. **service syslog status**

Note: Should say both are “stopped.”

26. **cd /etc/rc.d/init.d**

27. **chmod -x syslog**

Note: Makes syslogd and klogd init file *not* executable.

28. **ls**

Note: Syslog should be black, not green.

29. **chkconfig --del syslog**

30. **chkconfig --list | grep on | sort**

Note: Should not see syslog.

At this point, you have installed `syslog-ng`, started it, configured it to run on startup, and disabled `syslogd`. The process to install this syslog client is fairly involved, but it will provide your network and/or system with a more versatile and powerful logging service. It is now sending logs the console, logged-in users, and log files on the host system. Now the configuration file, `syslog-ng.conf`, must be edited to enable remote logging and to ensure that the proper logs are being sent to both local and remote destinations.⁶⁴

```
=====BEGIN=====
# Simple syslog-ng.conf file

# Some common options() with default values entered
options { use_fqdn(no); use_dns(yes); sync(0); time_reopen(60);
create_dirs(no); };

# Basic sources for log messages on a Linux operating system
source s_src { pipe ( "/proc/kmsg" log_prefix ( "kernel: " ));
unix_dgram("/dev/log"); internal(); };

# Create logging in both a single local file and a remote log server
destination d_local { file ( "/var/log/syslog-ng.all" ); };
destination d_server { udp ( "192.168.4.2" port(514) ); };

# A simple filter that only exists for demo purposes
filter f_redundant { level(info); };

# The log command: this ties everything together
log { source(s_src); filter(f_redundant); destination(d_local); };
log { source(s_src); destination(d_server); };
=====END=====
```

Figure 59: Sample Config File

Following is an overview of the basic components of `syslog-ng`.

⁶⁴ For a more complete review, see <http://www.campin.net/syslog-ng/expanded-syslog-ng.conf>. Here you will find extensive documentation, numerous example `syslog-ng` config files, and option settings as well as directions on porting `syslog-ng` to a mysql database.

Syslog-ng.conf Structure⁶⁵

The basic `syslog-ng.conf` file consists of 5 parts:

- **Options{ }** are global characteristics for the config file.
- **Source{ }** defines where the log information shall be gathered from.
- **Destination{ }** defines the final output (for the local system).
- **Filter{ }** defines what specific information shall be gathered and processed.
- **Log{ }** makes the connection, taking from the `source{ }` whatever information is defined by the `filter{ }`, and then sending that information on to the `destination{ }`.

Options{ }

The options section defines global `options{ }` for the entire configuration file. Several of the more common options are listed in the sample file. All of them are shown with their default settings and, as they stand, serve no purpose other than illustration. Many of the `options{ }` are also available to be defined within the other four parts, or sections, of the configuration file. `Options{ }` that are defined within a specific `source{ }`, `destination{ }`, `filter{ }`, or `log{ }` definition generally take precedence over the globally defined `options{ }`.

Source{ }

The `source{ }` from where the logs are gathered can be a fifo/pipe, file, internal source, tcp/udp connection, sun-stream (Solaris), and/or unix-stream/unix-dgram. For a RedHat Linux box, the `source{ }` for the bulk of messages is the unix-stream (for kernel versions that are pre 2.4.1) or the unix-dgram (for kernel versions 2.4.1 and later). The `source{ }` from which messages are gathered is `/dev/log`, which is a connectionless datagram UNIX socket in all recent and future distributions of Linux. If unix-stream is used on these boxes instead of unix-dgram, kernel messages will not be captured. Since it is connectionless, messages could be lost on an overloaded host.

Another important `source{ }` for RedHat Linux boxes is piped from `/proc/kmsg`, which is a second source of kernel messages on RHL systems. Note that the piped command adds “kernel:” to the text of the log message for easier identification. The last `source{ }` command that is shown in the demo config file is “`internal()`.” This includes all messages that the syslog service creates internally. This line should always be present regardless of the UNIX/Linux system on which it is running.

Separate or All-in-One. The `source{ }` section of the config file can be separated into several sources or it can be all combined into one source, as is shown in the demo file. It could have been separated into three individual sources if more flexibility and versatility was required. As the configuration file becomes increasingly more complex, it may be more helpful to be

⁶⁵ <http://www.campin.net/syslog-ng/expanded-syslog-ng.conf>

able to break the sources out separately. The example, however, is designed entirely for simplicity and thus is all in one source{ }, s_src.

Naming Convention. The naming convention for the source{ }, filter{ }, and destination{ } sections is also worth noting as it may provide greater clarity when reviewing the file at a later date. The names are generally prepended with “s,” “f,” and “d,” respectively, and then given descriptive names that make it easy to determine the intended purpose.

Destination{ }

A destination{ } can be defined as a fifo/pipe, file, program, tcp/udp connection, usertty, and/or unix-stream/unix-dgram. Our sample file shows a file definition for locally saved logs and a udp connection to the remote log server. The file destination{ } offers a plethora of “macros” which can be used to create a set of files according to the macro chosen. The following example would place the logs for each host into its own directory and the logs for each day of the week into a different file:

```
destination d_dest { file("/var/log/$HOST/logfile.$WEEKDAY"); };
```

Thus, there would be a separate directory for each device on the network, and within each directory would be a seven-day rotating set of log files for every day of the week. The macros available include Date, Facility, Hour, Minute, Second, Time Zone, etc. Additionally, there are several options{ } available for file destinations, such as compression, encryption, directory creation, and directory and file permissions.

The other destination{ } is the udp connection created to send logs to the remote log server from port 514. The only required parameter is the IP address or hostname of the remote log server that you want the messages logged to. The sample file shows the specific designation of port 514. Although this is probably good practice, it is not required as the default destination port is port 514. TCP could also have been used, allowing the use of SSL/TLS, STunnel, or SSH for encryption and authentication. UDP can still be used along with IPSec for added security.

Infinite Loop. One last point that is important to remember is to make sure that you do not have multiple hosts forwarding messages and thus creating a loop. One misdirected log can result in DoS or severely limit your network as that packet is continuously forwarded.

Filter{ }

This is where things can get tricky and confusing. Filters can be very simple or they can become quite complex with multiple criteria connected with various logical operators. One filter{ } may even call another filter{ } to evaluate its resultant value. This can be effected within a filter{ } itself, or by “chaining” filters together within a single log{ }. However, this greater complexity enables the greater flexibility and power that is available from syslog-ng’s extended configuration possibilities. Most often, filters are created to separate logs by Facility, Severity Level, and/or Hostname. The only thing that the filter in the sample file

does is to filter out all debug-level messages. This may be valuable in some cases, but in this case it is arbitrary. All decisions to filter should be based upon approved and documented policies and procedures, which have been developed based upon the mission of the organization, the purpose of the hosts, and the value placed on their continuous operation.

Log{ }

As mentioned above, the `log{ }` binds together the other parts, taking messages from the source, according to what the `filter{ }` and `options{ }` allow, and then sending those messages to the appropriate `destination{ }`. A `log{ }` must contain a `source{ }` and a `destination{ }`, though multiples of these can be included. If no filter is explicitly specified, the default filter of everything is implicitly applied.

Further Resources

Read Chapter 10 from *Building Secure Servers with Linux* [O'Reilly 02].

Review the sample `syslog-ng.conf` files that come with the `syslog-ng` download. If the tarball was downloaded into `/usr/local`, the samples are located in the `/usr/local/syslog-ng-x.x.x/contrib/` and `/usr/local/syslog-ng-x.x.x/docs` directories.

The online `syslog-ng` FAQ [Campi 03] has a list of important links that offer a wealth of knowledge on the subject of logging UNIX/Linux systems. The links provided in this FAQ—particularly Balazs Scheidler's `syslog-ng` home page and the expanded sample `syslog-ng.conf` site—are especially valuable, as they provide in-depth, advanced configurations that mere mortals can comprehend!



Remote Logging: Syslogging in Windows—NTsyslog Client

Freeware graphical Windows syslog client

Provides granular configuration capabilities

Selecting which logs/events to send is user-friendly and within standards

Demo: NTSyslog

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4.5.11 NTsyslog Daemon for Windows

The syslog daemon is not included in Windows operating systems. Therefore, an aftermarket product must be found from another vendor. NTsyslog⁶⁶ has a freeware product that allows a Windows box to send the event viewer messages remotely as syslog messages. The basic install has a default setting to send all logs generated by the Windows Audit Policy to the syslog server. NTsyslog also has a freeware GUI that allows administrators to access registry subkey settings that can be modified to filter what is sent to the syslog server.

⁶⁶ <http://ntsyslog.sourceforge.net/>

NTsyslog Daemon Installation Instructions

1. Download the latest version of NTsyslog from this site:
http://sourceforge.net/project/showfiles.php?group_id=36242&release_id=117709
2. Extract all the files from the zip file into a new folder.
3. Copy `ntsyslog.exe` from the new folder to `c:\winnt\system32`
4. Copy the REGEDIT4 registry key from the box at right into a Notepad text file.
5. In the third line, modify “YourSyslogServer” to the hostname or IP address of your actual remote logging host.
6. Save the file as `ntsyslog.reg`
7. Run .reg file by double-clicking it and selecting Yes and OK when prompted.
8. Open a cmd prompt from Start\Programs\Accessories.
9. At the command prompt (`C: \>`), type **`ntsyslog.exe -install`** (there should be a message similar to “NTsyslog installed”).

REGEDIT4

[HKEY_LOCAL_MACHINE\SOFTWARE\SaberNet]
"Syslog"="YourSyslogServer"

[HKEY_LOCAL_MACHINE\SOFTWARE\SaberNet\Syslog\System]
"Information"=dword:00000001
"Warning"=dword:00000001
"Error"=dword:00000001
"Audit Success"=dword:00000001
"Audit Failure"=dword:00000001

[HKEY_LOCAL_MACHINE\SOFTWARE\SaberNet\Syslog\Security]
"Information"=dword:00000001
"Warning"=dword:00000001
"Error"=dword:00000001
"Audit Success"=dword:00000001
"Audit Failure"=dword:00000001

[HKEY_LOCAL_MACHINE\SOFTWARE\SaberNet\Syslog\Application]
"Information"=dword:00000001
"Warning"=dword:00000001
"Error"=dword:00000001
"Audit Success"=dword:00000001
"Audit Failure"=dword:00000001

Now go back to the NTsyslog folder and double click the NTsyslogCTRL.exe icon to open the GUI. Once you open the NTsyslogCTRL GUI you will see the following screen:

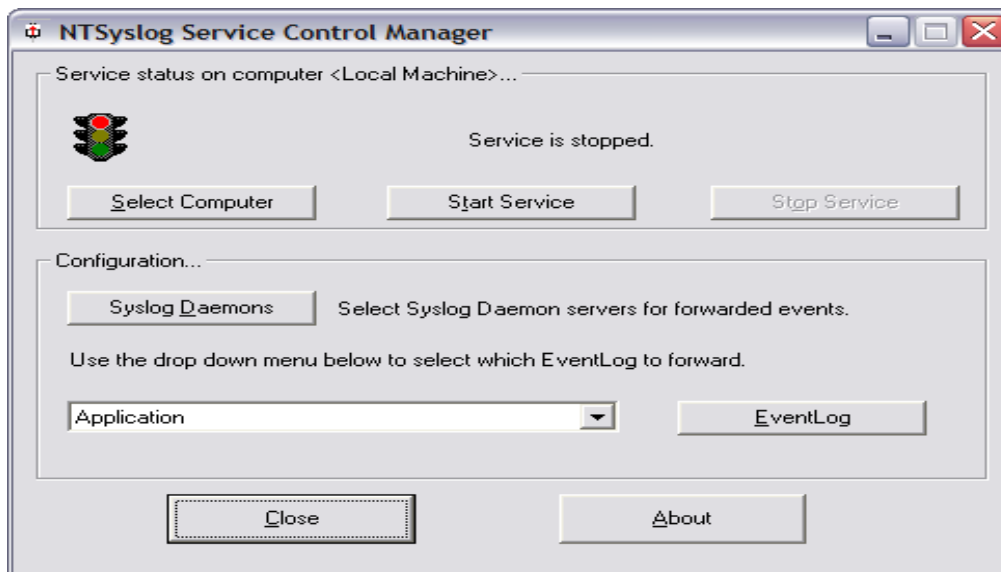


Figure 60: NTsyslog Service Control Manager (Main Control Panel)

Notice that the stoplight is red and the message says “Service is stopped.” There are a couple of settings that must be made to get the basic service running. There are a few more settings that can be made to modify the sending of logs to the remote server. Click the Select Computer button to see this screen:

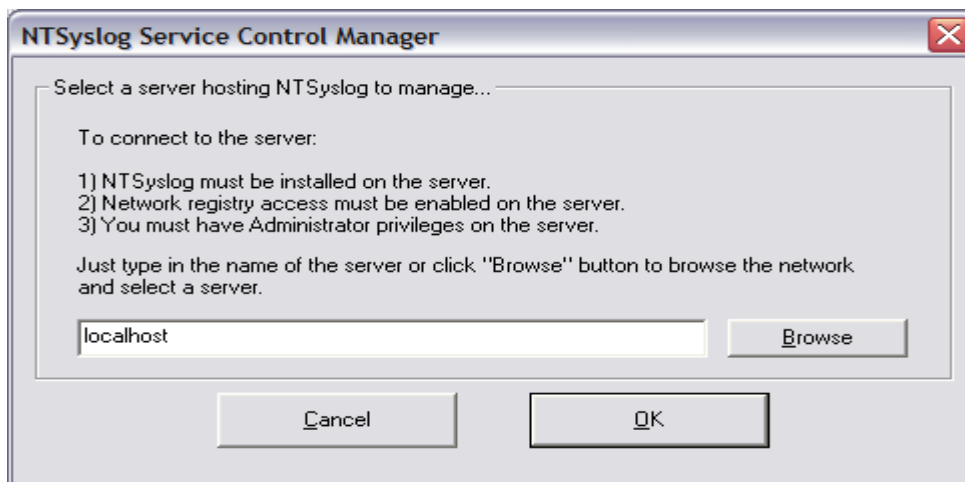


Figure 61: NTsyslog Service Control Manager (Enter the Client Hosting NTsyslog)

Enter the hostname or IP address of the local computer from which the local logs should be sent. Then, click the Syslog Daemons button to see the following screen:



Syslog Server Settings

Enter Syslog Daemons IP Addresses to which forward events...

Primary Syslog Daemon : 127.0.0.1
Required

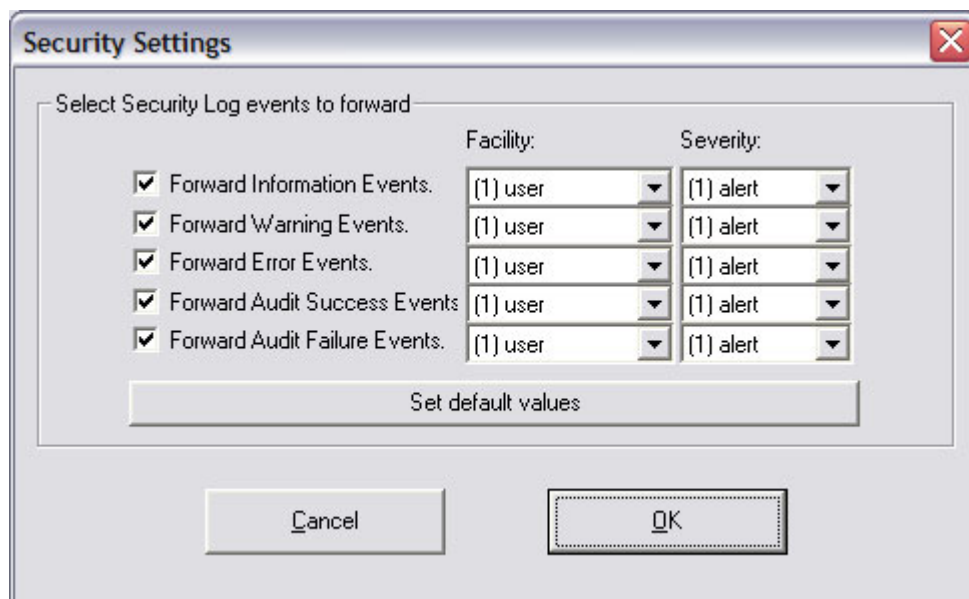
Backup Syslog Daemon :
Leave blank field if you don't have a backup Event Master server.

Cancel OK

Figure 62: NTsyslog (Syslog Server Settings)

Enter the hostname or IP address of the remote server to which the logs from this host should be sent. The local loopback address is currently entered in this screen. This is the correct setting if the local host is also the remote log server for the network. If the System server is on another machine, that host's hostname or IP address should be entered. After this, click the Start Service button. In the future when any configuration change is made, the service must be stopped and then restarted in order for the service to run under the new configuration.

The service is now running and logging everything to the remote log server. To modify which logs will be sent to the remote log server, select from the drop-down list and click the EventLog button. The configuration screen for security logs looks like this:



Security Settings

Select Security Log events to forward

	Facility:	Severity:
<input checked="" type="checkbox"/> Forward Information Events.	(1) user	(1) alert
<input checked="" type="checkbox"/> Forward Warning Events.	(1) user	(1) alert
<input checked="" type="checkbox"/> Forward Error Events.	(1) user	(1) alert
<input checked="" type="checkbox"/> Forward Audit Success Events.	(1) user	(1) alert
<input checked="" type="checkbox"/> Forward Audit Failure Events.	(1) user	(1) alert

Set default values

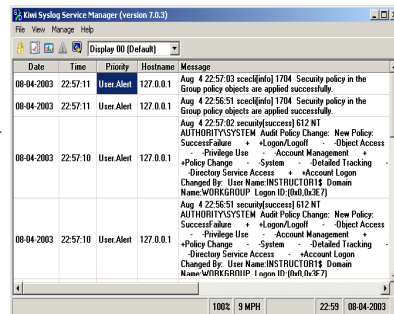
Cancel OK

Figure 63: NTsyslog (Security Settings)

Remote Logging: Kiwi Syslog Server Manager

Freeware tool by Kiwi Enterprises (Kiwi Syslog Daemon)

- Filters by priority or time of day
- Displays messages to screen, save logs to a file, relays to another host, and send SNMP trap, and/or terminate message
- Set log file size and allows basic log rotation
- Operates with UDP or TCP



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4.5.12 Kiwi Syslog Daemon for Windows

Kiwi Syslog Daemon⁶⁷ is a freeware syslog daemon for Windows. It receives, logs, displays, and forwards syslog messages from hosts such as routers, switches, UNIX hosts and other syslog enabled devices. There are many customizable options available.

Kiwi offers a wide range of configuration options: it allows for rotation and truncation of log files, permits a customizable real time interface that can filter high level events while logging the remaining events to a file, and can operate with either TCP or UDP syslog traffic.

Kiwi also offers a whole suite of related products that are free. One very useful tool is Kiwi Secure Tunnel Tool. It allows for a secure tunnel to be established via the Internet using an open source VPN solution which implements Blowfish⁶⁸ encryption. This is a free and easily implemented method of securing syslog traffic on your network or across several networks.

⁶⁷ This definition was taken from the home page for Kiwi Syslog Daemon:
<http://www.kiwisyslog.com>.

⁶⁸ For more information on Blowfish Encryption, see <http://www.schneier.com/blowfish.html>.

Remote Logging: Kiwi Syslog Daemon Service Manager (Windows)

Point-and-click installation

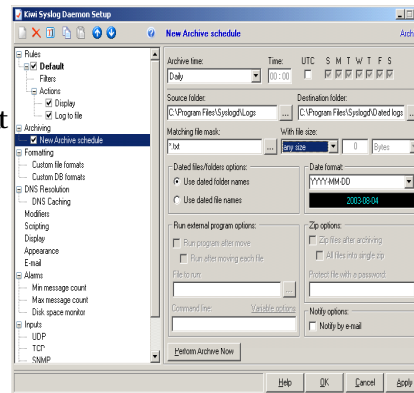
Simple rule configuration

Clean and meaningful output

Log files exportable

Scalable

Demo: Kiwi Daemon



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Kiwi Syslog Daemon Service Manager for Windows

The Kiwi Syslog Daemon Service is a point and click windows install that nevertheless offers many configuration options. Starting the Kiwi Syslog Service is fairly easy. However, it is important to note that by default all messages will be sent to be viewed and saved. This may create an overwhelming screen that becomes unusable very quickly. A few alterations to the default settings will make Kiwi a usable interface that provides meaningful information.

Because Kiwi is flexible, it is possible to view only high level events and at the same time have the remaining non-critical events sent directly to the log file. This allows an administrator to view only high level events that will require immediate action and save the remaining events for scheduled reviews.

In addition, it is possible to use several displays to filter on specific events or hosts. This option can allow an administrator to watch selected systems separately on one screen simultaneously.

To get you started, we have provided a detailed overview of the installation process and a walk-through of the more useful configuration options available:

Installing Kiwi Syslog Daemon

1. Download the service edition of Kiwi Syslog Daemon from <http://www.kiwisyslog.com/>.
2. From the same site, download Kiwi SyslogGen (a pseudo-random syslog message generator you can use to test your setup).

3. Install Kiwi Syslog Daemon and then Kiwi SyslogGen.
4. Go to Programs and open both Syslog Daemon and SyslogGen.
5. Click to make the Syslog Daemon window active.
6. From the Manage menu, select Install the Syslogd Service.
7. A message should tell you that the service is installed.
8. From the Manage menu, select Start the Syslogd Service.
9. After the service starts, select File > Send Test Message to Localhost. You should see an entry in the viewer.
10. Click to make the SyslogGen window active.
11. Under Select Message Text to Send, select a message.
12. Click Send.
13. Click the Syslog Daemon window to make it active and verify that the message was sent (= install OK).

Configuring Kiwi Syslog Daemon

Select File > Properties or click the icon with the red check-mark in the menu bar. You will see the Kiwi Syslog Daemon Setup window (Figure 64):

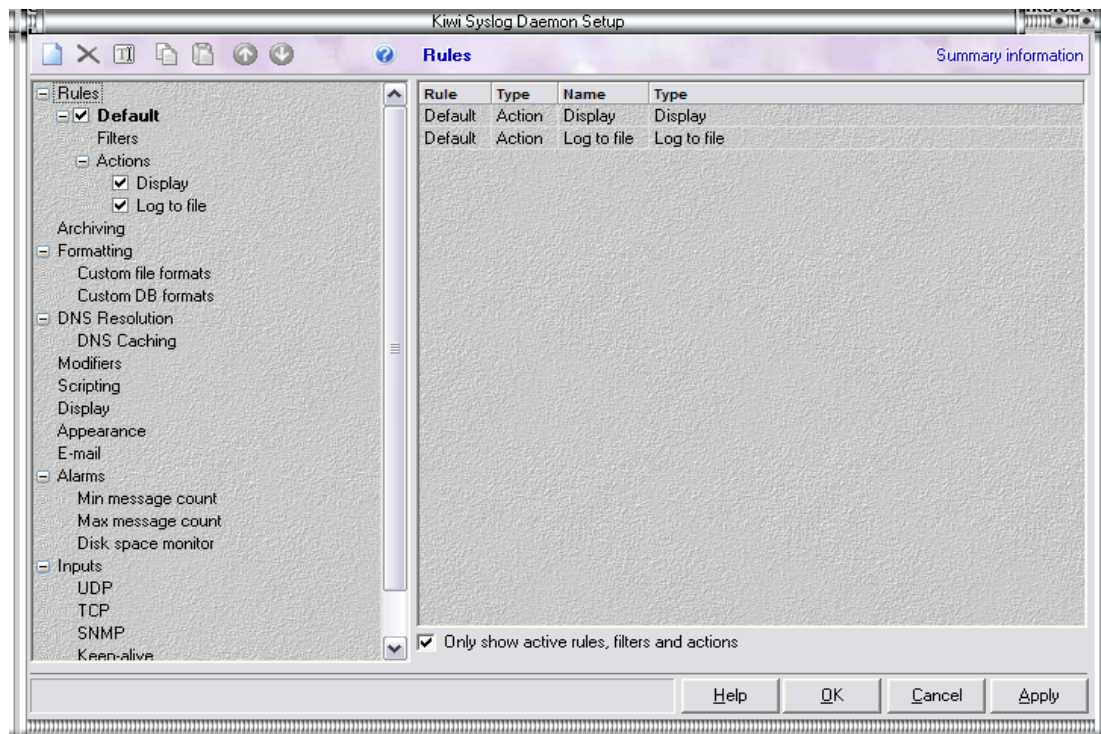


Figure 64: Kiwi Syslog Daemon Setup

This window offers several configuration settings as freeware, and even more if a license is purchased for the full version. All of the settings are currently default.

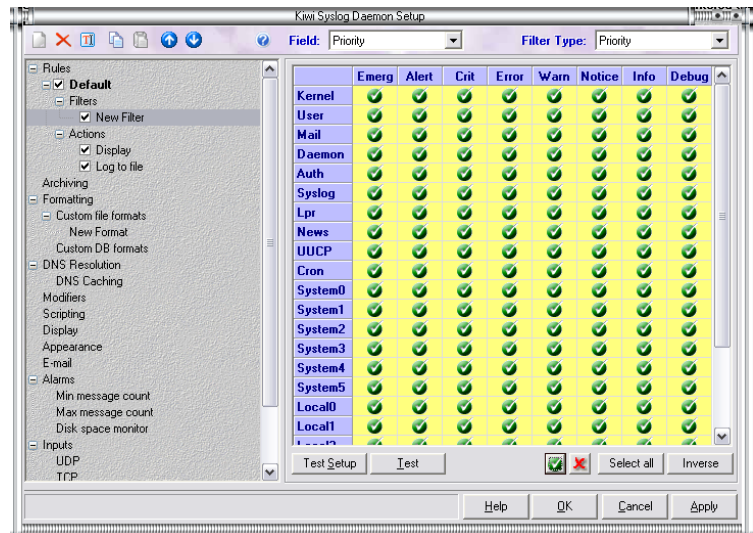
Rules determine the filter settings. Similar to all the syslog clients, filtering can be done by Priority. It can also be done by Time of Day.

Filters

In the left-hand panel under Rules > Default, right click Filters. Select Add filter.

Priority can be selected from the first drop down list and then priority is automatically selected in the second list. Note the matrix of Facilities and Severity Levels.

Time of Day can be selected from the first drop down list and then Time of Day is automatically selected in the second list. Note the matrix of days and times.

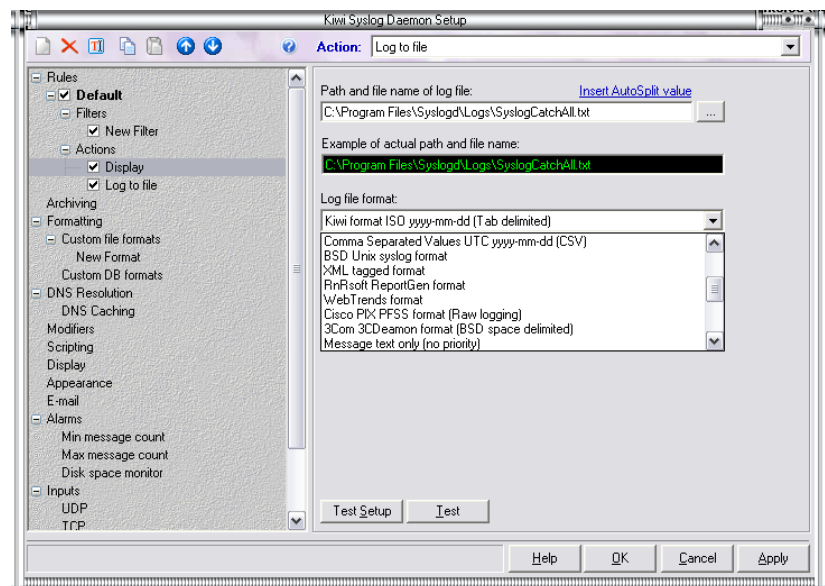


Actions

Right click Actions to select Add Action. The Action drop-down list provides the following options:

Display provides 10 different display screens to display different filter configurations. These 10 different displays can be used to view various Facilities and/or Severity Levels, or any combination thereof.

Log to File can create a file with active modifiers depending on Date, Time, Priority, Source, etc. The file can also be created in any folder you want. The file format can be chosen from a preset list in this window or you can configure your own file format under the Formatting section below. Note that the “BSD UNIX Syslog Format” in the drop down list is RFC 3164 format.



Forward to Another Host allows you to forward files to another IP address or Hostname. This window also allows you to choose whether the syslog message should be modified before sending.

Formatting allows you to create your own template for the structure of syslog messages that are saved to a file or to a database. Add a new custom file format to see the many options for creating different file formats.

Display

At the top of this screen, you can rename your display screens. It is also helpful to check the box to display gridlines in the viewer.

Email

In the freeware version, email notifications are limited to Min/Max Message Count alarms, Disk Space alarms, and daily statistics. These notifications are helpful however. The Alarms section must be enabled in order to receive email notifications.

Alarms

As mentioned above, these are alarms that notify in the event of too many or too few messages or if disk space is running too low.

Inputs

This is where you can configure the daemon to listen for syslog messages on UDP 514, TCP, and/or SNMP.

Computer Time Synchronization

Needs for synchronized time?

- Critical for secure document timestamps (cryptography)
- Coordination of IDS, Firewall, network monitoring, Snort, syslog log files
- Necessary for meaningful transaction controls and logging on a distributed database
- Essential for secure Web servers, email servers, FTP servers, domain controllers, etc.
- Fundamental to the goal of moving to Coordinated Universal Time (UTC)

4.6 Computer Time Synchronization

Why synchronize computer time? On any computer network, servers and services are dependent on the system time that is running them. Most, if not all, operating systems and applications generate some sort of log with a time and date stamp: IDSs, firewalls, Windows, UNIX syslog, email servers, and Web servers all use time and date for logging. For this reason, without time synchronization these files become almost impossible to compare and review. Thus, a key component for any security system is network time synchronization, not to mention any meaningful administration of a system is going to rely of the synchronization of the time across the network.

In addition to operating systems and applications, there are other areas that depend on the time synchronization of computers. E-commerce is an example of an enormous industry that is growing larger and larger every day and is completely dependent on the time synchronization of servers and networks. When credit cards are used to purchase goods over the Internet, a multitude of invisible processes enable a site to complete the following essential tasks.

- Provide a secure environment for buyers to conduct purchases.
- Verify credit cards using a credit card verification service (a service which checks to see whether the credit card account has enough funds to cover the purchase).
- Use a merchant service account to debit cards for the appropriate funds (a complicated series of communications in which the merchant service transmits the cardholder's transaction to the corresponding bank, the bank transfers the requested funds to the merchant service, and the merchant service forwards the funds to the site).

A single purchase will cause numerous systems to pass information back and forth in order to conclude the transaction. Time synchronization is critical here because if the transmission is interrupted by any sort of event or if the transaction is fraudulent, it will be necessary to look at the log files of numerous systems across several networks to identify all the interactions that were related to that single purchase. This task would be almost impossible without time synchronization.

So what is the standard source for synchronization? There are several, but we are going to discuss Network Time Protocol (NTP), described by David L. Mills as follows: “The Network Time Protocol (NTP) is used to synchronize the time of a computer client or server to another server or reference time source, such as a radio or satellite receiver or modem. It provides accuracies typically within a millisecond on LANs and up to a few tens of milliseconds on WANs relative to Coordinated Universal Time (also called UTC or atomic time) via a Global Positioning Service (GPS) receiver, for example. Typical NTP configurations utilize multiple redundant servers and diverse network paths in order to achieve high accuracy and reliability” [Mills 91].

Coordinated Universal Time (UTC) is synonymous with Greenwich Mean Time (GMT), so named because the town of Greenwich, England, is the location of the Prime Meridian (zero degrees longitude), the center of the time zone map. (“Mean” or “Meridian” time is the average time that the earth takes to rotate from noon to noon.) Because it is fixed all year and does not switch to daylight savings time, GMT sets the current date and time around the globe and is the official standard upon which all international time zones are based. Although GMT has been replaced by atomic time (UTC), it is still widely regarded as the standard for precision time and military time (sometimes called Zulu Time).⁶⁹

⁶⁹ For more detailed information regarding GMT, see <http://greenwichmeantime.com/>.

NTP Protocol - 1

Network Time Protocol (NTP) developed to synchronize clocks on host computers, routers, switches, servers across the Internet

Time accuracies in the order of nanoseconds when connected directly to a precision time source such as a radio or satellite

Unix NTP daemon ported to almost every host-based and server platform available—Unix, Windows, Macintosh, Cisco routers, Switches, etc.



Loran Receiver



GPS Receiver

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4.7 Network Time Protocol (NTP)

Over the last twenty years NTP has developed and grown into its current state, (NTP Fourth Generation). There is no current RFC documenting this version, but a significant information poll is available on the official NTP Web site at <http://www.ntp.org>, where you can also find overwhelming amounts of information and numerous links to enrich your understanding of NTP and SNTP.

The following excerpt is taken from Dr. Mills' NTP Executive Summary.⁷⁰ This provides a detailed overview of NTP and its goals and objectives:

The standard timescale used by most nations of the world is Coordinated Universal Time (UTC), which is based on the Earth's rotation about its axis, and the Gregorian Calendar, which is based on the Earth's rotation about the Sun. The UTC timescale is disciplined with respect to International Atomic Time (TAI) by inserting leap seconds at intervals of about 18 months. UTC time is disseminated by various means, including radio and satellite navigation systems, telephone modems, and portable clocks.

Special purpose receivers are available for many time-dissemination services, including the Global Position System (GPS) and other services operated by various national governments. For reasons of cost and convenience, it is not possible to equip every computer with one of these receivers. However, it is possible to equip some number of computers acting as primary time servers to synchronize a much larger number of secondary servers and clients connected by a common network. In order to do this, a distributed network clock synchronization protocol is required which can read a server clock, transmit the reading to one or more clients and adjust each client clock as required. Protocols that do this include the Network Time Protocol (NTP),

⁷⁰ The complete executive summary is available at www.eecis.udel.edu/%7Emills/exec.html.

Digital Time Synchronization Protocol (DTSS) and others found in the literature (See "Further Reading" at the end of this article.)

The synchronization protocol determines the time offset of the server clock relative to the client clock. The various synchronization protocols in use today provide different means to do this, but they all follow the same general model. On request, the server sends a message including its current clock value or *timestamp* and the client records its own timestamp upon arrival of the message. For the best accuracy, the client needs to measure the server-client propagation delay to determine its clock offset relative to the server. Since it is not possible to determine the one-way delays, unless the actual clock offset is known, the protocol measures the total roundtrip delay and assumes the propagation times are statistically equal in each direction. In general, this is a useful approximation; however, in the Internet of today, network paths and the associated delays can differ significantly due to the individual service providers.

The community served by the synchronization protocol can be very large. For instance, the NTP community in the Internet of 2002 includes over 230 primary time servers, synchronized by radio, satellite and modem, and well over 100,000 secondary servers and clients. In addition, there are many thousands of private communities in large government, corporate and institution networks. Each community is organized as a tree graph or *subnet*, with the primary servers at the root and secondary servers and clients at increasing hop count, or stratum level, in corporate, department and desktop networks. It is usually necessary at each stratum level to employ redundant servers and diverse network paths in order to protect against broken software, hardware and network links.

Synchronization protocols work in one or more association modes, depending on the protocol design. Client/server mode, also called master/slave mode, is supported in both DTSS and NTP. In this mode, a client synchronizes to a stateless server as in the conventional RPC model. NTP also supports symmetric mode, which allows either of two peer servers to synchronize to the other, in order to provide mutual backup. DTSS and NTP support a broadcast mode which allows many clients to synchronize to one or a few servers, reducing network traffic when large numbers of clients are involved. In NTP, IP multicast can be used when the subnet spans multiple networks.

Configuration management can be a serious problem in large subnets. Various schemes which index public databases and network directory services are used in DTSS and NTP to discover servers. Both protocols use broadcast modes to support large client populations; but, since listen-only clients cannot calibrate the delay, accuracy can suffer. In NTP, clients determine the delay at the time a server is first discovered by polling the server in client/server mode and then reverting to listen-only mode. In addition, NTP clients can broadcast a special "manycast" message to solicit responses from nearby servers and continue in client/server mode with the respondents.

A reliable network time service requires provisions to prevent accidental or malicious attacks on the servers and clients in the network. Reliability requires that clients can determine that received messages are authentic; that is, were actually sent by the intended server and not manufactured or modified by an intruder. Ubiquity requires that any client can verify the authenticity of any server using only public information. This is especially important in such ubiquitous network services as directory services, cryptographic key management and time synchronization.

NTP includes provisions to cryptographically authenticate individual servers using symmetric-key cryptography in which clients authenticate servers using shared secret keys. However, the secret keys must be distributed in advance using secure means beyond the scope of the protocol. This can be awkward and fragile with a large population of potential clients, possibly intruding hackers.

Modern public-key cryptography provides means to reliably bind the server identification credentials and related public values using public directory services. However, these means carry a high computing cost, especially when large numbers of time-critical clients are involved as often the case with NTP servers. In addition, there are problems unique to NTP in the interaction between the authentication and synchronization functions, since each requires the other for success.

The recent NTP Version 4 includes a revised security model and authentication scheme supporting both symmetric and public-key cryptography. The public-key variant is specially crafted to reduce the risk of intrusion, minimize the consumption of processor resources and minimize the vulnerability to hacker attack.

Copyright (c) David L. Mills 1992-2003



NTP Protocol - 2

Developed by Dr. David Mills at the University of Delaware

Version 3 has been in use since 1992. Version 4 is currently transitioning into use. It has an accuracy in the order of low microseconds (10 times that of Version 3) and provides for cryptographic authentication

Based on a hierarchical structure of primary (stratum 1), secondary (stratum 2), and tertiary time servers (stratums 3-16)

Simple Network Time Protocol (SNTP) is a lightweight version of NTP

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The implementation and installation of NTP is a very technical and lengthy process.⁷¹ This text will detail the SNTP Protocol and its implementation. Like NTP, the SNTP Protocol has been around for some time and is always developing. SNTP is currently in its fourth version (RFC #2030 1996). SNTP and NTP are similar in that they both can operate as client and/or sever. How they do that is what makes them different.

NTP is a complex program that will (when acting as a time server) help to make the local time keeping more accurate. This is accomplished through the NTP Drift File. NTP will keep a record of the local (internal clock) time and its inaccuracies. Over time, NTP will improve the ability of the internal clock to maintain accurate time longer in the event that the NTP Server becomes disconnected from the server at the next highest stratum. In addition, NTP is able to filter out anomalous time readings from upstream stratum to avoid adversely affecting the local network time. Remarkably, the accuracy of synchronization with a properly configured NTP Server/Network is in a range approaching the low milliseconds.

SNTP does not maintain a drift file, and is thus completely dependant on the upstream stratum's time. SNTP has no ability to filter anomalous time from upstream stratum, it will simply average the times and update based on that sum. Its degree of accuracy is in the range of microseconds rather than milliseconds. Despite these lesser abilities, SNTP is a very powerful and simple tool to implement across a network. More importantly, it is also scaleable.

⁷¹ Full documentation of this process and a library of related materials are free and available at <http://www.ntp.org>.

NTP Protocol - 3

Avoid geographically isolated time servers

NetTime freeware operates as a point and click SNTP client or server (Windows based) or a simple registry hack to allow Windows clients to use NTP.

Unix offers the `ntpd` daemon.

Demo: NetTime Client and Server

```

REGEDIT4

[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\
Services\W32Time\Parameters]
"LocalNTP"=dword:00000000
"NTPServer"="yourNTPserver"
"Period"=dword:00000000
"Type"="NTP"
"Log"=dword:00000064
"WriteLog"="True"
    
```

The NTP and SNTP protocols were developed by the UNIX community. As a result, most UNIX systems will have the NTPd daemon preloaded. All that is needed to make a UNIX machine a NTP/SNTP client is to modify the `ntp.conf` file to connect to the network time server and query that NTP/SNTP server periodically.

4.7.1 Configuring the NTPd Daemon (the `ntp.conf` File)

Type the bold text exactly as it appears, except where you see “NTPServer.” Replace the text “NTPServer” with the hostname or IP address of the actual network time server to which you will synchronize:

1. Open the “vi” text editor by entering the following:
vi /etc/ntp.conf
2. Press the [Insert] key to be able to modify text in this file.
3. Scroll down to the section titled “--- Our Timeservers ---”
4. At the end of this section, add the following two lines to identify the NTP server:
restrict NTPServer mask 255.255.255.255 nomodify notrap noquery
server NTPServer
5. To save and close this file, press the [Esc] key and enter:
:wq
6. To remove the old step-tickers file, enter
rm -f /etc/ntp/step-tickers

7. To populate the step-tickers file with our time server, type
echo "NTPServer" > /etc/ntp/step-tickers
Note: The hostname or IP address must be in double-quotes ("").
8. To see what is in the step-tickers file, type
cat /etc/ntp/step-tickers
9. To start the NTP Daemon, type
service ntpd start
Note: You should see messages saying that ntpd is synchronizing with the time server and that ntpd is starting. Both should be "OK."
10. To check that the service is running, type
service ntpd status
11. To open the editor to create a new cron job, type
crontab -u root -e
12. Press the [insert] key.
13. To create a cron job that restarts ntpd every minute, type
*** * * * * /etc/rc.d/init.d/ntpd restart**
14. Save and close as in step 5 above.
15. To set a runtime command that automatically starts ntpd at run levels 3, 4, and 5 whenever the operating system is started, type
chkconfig --level 345 ntpd on
16. To show the runtime list, type
chkconfig --list | grep on | sort
Make sure that ntpd is included and that levels 3-5 are on.
17. To display the host system's date and time, type
date
Compare this to the NTP server's system time to ensure that it is synchronized.

Now, monitor the host time against the network time server's time to ensure that the service is working correctly.

NTP and SNTP clients in Windows are another matter. Windows XP ships with a simple built-in NTP/SNTP client. Under the date and time settings there is an option to select a time server. Simply enter the name of the time server and XP will synchronize its time. Keep in mind that this is an SNTP client only setting.

4.7.2 Creating an SNTP Client in Windows 2000

In Windows 2000, an SNTP client can be created with a short registry edit (W32Time).

Below are the registry and service changes that allow Windows clients to use SNTP/NTP:⁷²

1. Copy the text in the box below and paste it into Notepad:

```
REGEDIT4
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\W32Time\Parameters]
"LocalNTP"=dword:00000000
"NTPServer"="yourNTPserver"
"Period"=dword:00000000
"Type"="NTP"
"Log"=dword:00000064
"WriteLog"="True"
```

LocalNTP tells the computer whether it should act as an NTP server (0=false).

NTPServer is the Hostname or IP address of the NTP server.

Period defines how often to check (0 = daily).

Type is the type of time service.

Log is needed to enable logging.

WriteLog is needed to enable logging.

2. Save the Notepad file with a “.reg” extension. Double click on the file. It will modify the WinTime registry to allow the host to be a client of a SNTP/NTP Time Server.
3. Start the WinTime service from Start > Administrative Tools > Services. Scroll down, double-click “Windows Time,” and select the Automatic start-up type. This will allow WinTime to automatically check and update the local time with the selected NTP/SNTP Server.

4.7.3 Establishing an SNTP Server in Windows 2000

Establishing an SNTP Server in Windows is a relatively easy process. A wonderful freeware tool, NetTime,⁷³ allows a Windows system to become a SNTP server or client. NetTime will run as a service and works well with most networked devices. (NetTime is still an SNTP server, not an NTP server.) NetTime has an easy point-and-click installation process. Once installed, NetTime’s main interface window (see Figure 65) will prompt you to select time servers. (If you click the Find buttons, you can choose a time server from the Find a Time Server window represented in Figure 66.) You can select up to five time servers for NetTime to query. NetTime will take the average time of all of these external servers that agree to within a certain parameter of deviation and will discard the times of any servers that lie too far outside the majority opinion. Clients will synchronize with that averaged time.

⁷² These directions were taken from <http://www.cs.ucsb.edu/~kip/windows/>

⁷³ NetTime is free and available for download at <http://nettime.sourceforge.net/>. This site is the source for all documentation related to NetTime.

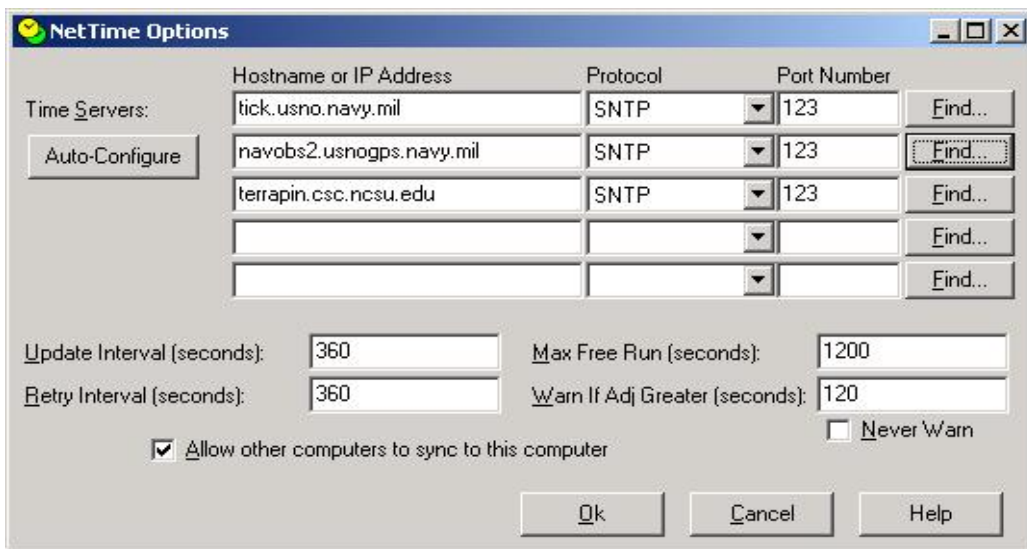


Figure 65: NetTime Interface (NetTime Options)

It is important to select at least three different time servers so that if a couple of them are unavailable or putting out an incorrect time, the majority of the servers will still be able to agree upon one consistently correct time synch. Make sure that the netlag is as small as possible. Netlag is the delay in time between your system and a time server. All your choices should have similar netlags. To minimize netlag, choose time servers that are geographically close together and that have the shortest possible netlag. These factors will greatly affect the accuracy of your network time. You should also avoid geographically isolated time servers, as they will likely have longer netlag delays.

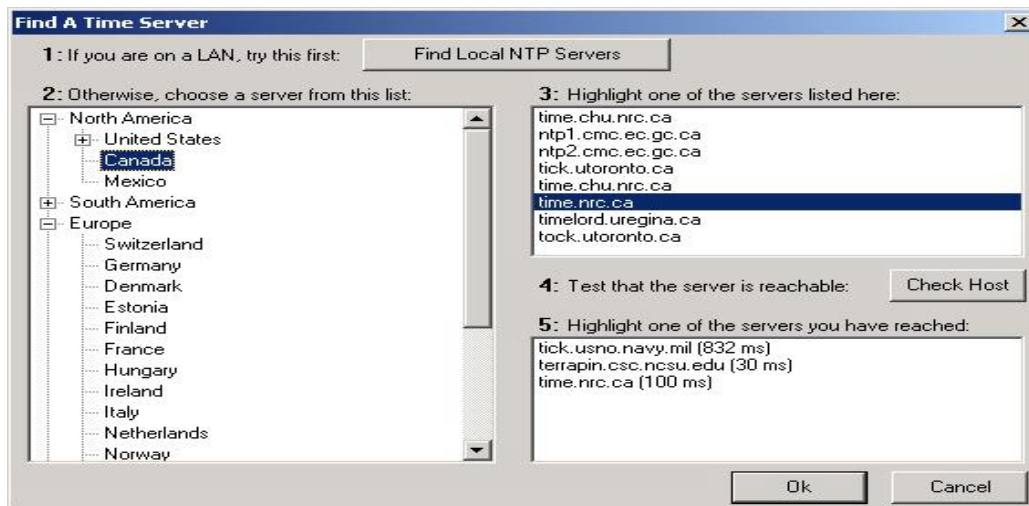


Figure 66: NetTime Interface (Find a Time Server)

Once you have selected and verified your time servers, all that is needed to establish the network service is to check the “allow other computers to sync to this computer” box. At this

point you will need to configure the client hosts on the network to point to the IP address of the system running NetTime in server mode. Everything else happens automatically.

4.7.4 Establishing an SNTP Server in a Windows Domain

Within a windows domain, time synchronization is established by kerberos between the hosts and the domain controller. Synchronizing the domain controller's time to an external NTP Stratum 1 server by utilizing a third party software like NetTime requires modification of the W32Time registry settings on the domain controller. Once this is accomplished, the domain clients automatically synchronize their system time to the domain controller.

One modification to the W32Time registry setting is necessary to accomplish this task. The value for the "Period" setting under the "HKLM/System/CurrentControlSet/Services/W32Time/Parameters" key should be set to "nosync."

Hive: HKEY_LOCAL_MACHINE

Key: \System\CurrentControlSet\Services\W32Time\Parameters

Name: Period

Entry: nosync

This will stop the domain controller from trying to establish a connection to an external NTP server and allow a third party application, such as NetTime, to replace this functionality.

Whichever application is utilized, it must be configured to ensure that it is only synchronizing the domain controller's system time clock and is not functioning as the NTP server on the domain by offering network synchronization. The domain controller's functionality will perform the network synchronization of the hosts on the network.

For a full discussion on this topic, refer to the Microsoft white paper *The Windows Time Service* [Brandolini 01].

Interacting with Log Files

Most logs are saved as flat files

Know where source logs are being stored

Compare remote and local logs to ensure integrity

Save log files to a “write once” medium

Always work with a copy of the log files

Rotate log files and archive using good naming conventions

[illegible]

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4.8 Interacting with Log Files

Up to this point you have learned a lot about remote logging and some basic configurations that should help you understand what's being logged. Most systems running on a network produce some sort of log messages. The format of these logs can be different from vendor to vendor and even from version to version. However, almost all the log files will be saved as "flat files." Flat files are simple text files that are comma, tab, or space delimited. This is a common format that can be easily exported to a variety of programs.

One of the most important responsibilities a system administrator has is to know where all local and remote log files are being stored. For critical systems, it is a best practice to have local files forward to a remote log server. The files should be stored on some sort of write once medium to protect the data. This way, the critical data is protected from being erased or deleted either locally or remotely.

It is equally important to rotate all the log files, establish an archiving procedure, and standardize naming conventions for use in the long term. If log files just run together and are not organized, it becomes very difficult to organize them later. Therefore, files should be named consistently and rotated at equal intervals. For example, an administrator might decide to rotate all the files once a week, saving the week's logs in files named by system and date. A file named "firewall-03-52" would identify the log's system (firewall), year (03), and week of the year (52). This schedule and naming scheme would be adopted across the network. Such consistency allows for easier analysis in the future and improves your ability to reconstruct events.

Never use the original log files or a production network system to conduct a log file analysis. Always make a copy and use the copy for analysis.

Log File Analysis

IIS Log File Format (Windows)

```
#Software: Microsoft Internet Information Services 5.0
#Version: 1.0
#Date: 2003-08-01 18:50:37
#Fields: date time c-ip cs-username s-sitename s-computername s-ip s-port cs-method cs-
uri-stem cs-uri-query sc-status sc-win32-status sc-bytes cs-bytes time-taken cs-version cs-
host cs(User-Agent) cs(Cookie) cs(Referer)
2003-08-01 18:50:37 128.2.243.155 - W3SVC1 BUCKWHEAT 128.2.243.156 80 GET
/sfts/- 302 0 291 285 10 HTTP/1.1 128.2.243.156
Mozilla/4.0+(compatible;+MSIE+6.0;+Windows+NT+5.0) - -
2003-08-01 18:50:37 128.2.243.155 - W3SVC1 BUCKWHEAT 128.2.243.156 80 GET
/sfts/- 200 0 559 286 10 HTTP/1.1 128.2.243.156
Mozilla/4.0+(compatible;+MSIE+6.0;+Windows+NT+5.0) - -
```

4.8.1 Analyzing IIS Log File Format

Since most networks offer some kind of Web services, a review of Microsoft's ISS logs (Windows Web Page Log Files) format is a good place to begin. The log file format is basically a space delimited flat file. When setting up the logging options on a Windows Web server there are several choices to make. Logging as much as possible is a best practice that will aid greatly in adding forensic abilities, but in reality it is always a trade-off between performance and disk space.

Because Web servers offer public services and therefore must allow open connections, this will likely be the place that prospective intruders try first. This is a reality and a fact that most administrators deal with on a regular basis.

An article by Mark Burnett, "Forensic Log Parsing with Microsoft's Log Parser" [Burnett 03], offers a very insightful method of examining ISS log files of an e-commerce site to identify an intruder. Two very interesting and useful techniques he illustrated are to use a SQL database to review the log file (he used Microsoft Log Parser⁷⁴) and to use the "User Agent" field in the ISS logs. Using the database allows greater flexibility in performing searches on the data set. Using the User Agent field in the ISS Log provides valuable insight by showing the configuration of the intruder's browser:

"+(compatible;+MSIE+6.0;+Windows+NT+5.0)." The article suggests tracking this field and the client IP through the log to create a history of contacts and—more importantly—to see whether this same browser configuration has been used with other client IPs. This could be an indication that the intruder is using multiple IP addresses (spoofed) from the same host browser. This is not a surefire method but it can be helpful in conjunction with other tools and methods.

⁷⁴ <http://www.iisfaq.com/default.aspx?View=A525&P=141>

Below is a table from Burnett's article that outlines the fields in an ISS log file and provides a very useful description and explanation of its possible forensic usage.

Table 6: IIS Log Fields

Field Name	Description	Uses
Date (date)	The date of the request.	<i>Event correlation.</i>
Time (time)	The UTC time of the request.	<i>Event correlation, determine time zone, identify scanning scripts.</i>
Client IP Address (c-ip)	The IP address of the client or proxy that sent the request.	<i>Identify user or proxy server.</i>
User Name (cs-username)	The user name used to authenticate to the resource.	<i>Identify compromised user passwords.</i>
Service Name (s-sitename)	The W3SVC instance number of the site accessed.	<i>Can verify the site accessed if the log files are later moved from the system.</i>
Server Name (s-computername)	The Windows host name assigned to the system that generated the log entry.	<i>Can verify the server accessed if the log files are later moved from the system.</i>
Server IP Address (s-ip)	The IP address that received the request.	<i>Can verify the IP address accessed if the log files are later moved from the system or if the server is moved to a new location.</i>
Server Port (s-port)	The TCP port that received the request.	<i>To verify the port when correlating with other types of log files.</i>
Method (cs-method)	The HTTP method used by the client.	<i>Can help track down abuse of scripts or executables.</i>
URI Stem (cs-uri-stem)	The resource accessed on the server.	<i>Can identify attack vectors.</i>
URI Query (cs-uri-query)	The contents of the query string portion of the URI.	<i>Can identify injection of malicious data.</i>
Protocol Status (sc-status)	The result code sent to the client.	<i>Can identify CGI scans, SQL injection and other intrusions.</i>
Win32 Status (sc-win32-status)	The Win32 error code produced by the request.	<i>Can help identify script abuse.</i>
Bytes Sent (sc-bytes)	The number of bytes sent to the client.	<i>Can help identify unusual traffic from a single script.</i>
Bytes Received (cs-	The number of bytes received from the	<i>Can help identify unusual traffic to a</i>

bytes)	client.	<i>single script.</i>
Time Taken (time-taken)	The amount of server time, in milliseconds, taken to process the request.	<i>Can identify unusual activity from a single script.</i>
Protocol Version (cs-version)	The HTTP protocol version supplied by the client.	<i>Can help identify older scripts or browsers.</i>
Host (cs-host)	The contents of the HTTP Host header sent by the client.	<i>Can determine if the user browsed to the site by IP address or host name.</i>
User Agent (cs(User-Agent))	The contents of the HTTP User-Agent header sent by the client.	<i>Can help uniquely identify users or attack scripts.</i>
Cookie (cs(Cookie))	The contents of the HTTP Cookie header sent by the client.	<i>Can help uniquely identify users.</i>
<i>Referer (cs(Referer))</i>	<i>The contents of the HTTP Referer header sent by the client.</i>	<i>Can help identify the source of an attack or see if an attacker is using search engines to find vulnerable sites.</i>

As you can see, there are several logging options for Windows Web Servers. Now that you have a better understanding of the forensic uses of some of these options, you should be able to log more efficiently.

When you examine the ISS Log Files, look for a few basic things:

- multiple unsuccessful commands that try to run executable files or scripts
- numerous unsuccessful logon attempts from a single IP address (DoS attack)
- failed attempts to access and modify executable files (.bat)
- unauthorized attempts to upload files to a folder that contains executable files

Log File Analysis - 2

Tiny Personal Firewall Log File Format

9369	07/31/2003 13:19:48	Blocked	UDP	Incoming	128.2.66.159	50512	128.2.79.255	137	C:\WINNT\System32\ntoskrnl.exe
1	07/31/2003 13:18:47	07/31/2003 13:18:47			GUI%GUICONFIG#SRULE@INBLOCK#BLOCK-UDP				
9370	07/31/2003 13:19:58	Allowed	UDP	Incoming	128.2.76.24	137	128.2.79.255	137	C:\WINNT\System32\ntoskrnl.exe
6	07/31/2003 13:18:25	07/31/2003 13:18:56			GUI%GUICONFIG#SRULE@INBENABLEYOU#ALLOW-UDP				
9371	07/31/2003 13:20:03	Allowed	TCP	Outgoing	www.foxnews.com	192.88.115.211	80	128.2.67.221	1768 C:\Program
Files\Internet Explorer\EXPLORE.EXE	4	07/31/2003 13:19:00	07/31/2003 13:19:00		Ask all running apps				
9372	07/31/2003 13:20:03	Allowed	TCP	Outgoing	oascentral.foxnews.com	66.35.210.52	80	128.2.67.221	1771 C:\Program
Files\Internet Explorer\EXPLORE.EXE	2	07/31/2003 13:19:00	07/31/2003 13:19:00		Ask all running apps				
9373	07/31/2003 13:20:14	Blocked	UDP	Incoming	128.2.64.195	49170	255.255.255.255	5003	2 07/31/2003
13:19:09	07/31/2003 13:19:12	Block_all							
9374	07/31/2003 13:20:49	Allowed	UDP	Outgoing	128.2.79.255	138	128.2.67.221	138	C:\WINNT\System32\ntoskrnl.exe
2	07/31/2003 13:19:32	07/31/2003 13:19:45			GUI%GUICONFIG#SRULE@INBLOCK#BLOCK-UDP				
9375	07/31/2003 13:20:49	Blocked	ICMP	Incoming	128.2.4.3.3	128.2.67.221	3	2	07/31/2003 13:19:32
07/31/2003 13:19:45	Block_all								
9376	07/31/2003 13:20:49	Blocked	ICMP	Incoming	128.2.4.2.3	128.2.67.221	3	2	07/31/2003 13:19:32
07/31/2003 13:19:45	Block_all								
9377	07/31/2003 13:20:49	Blocked	ICMP	Incoming	128.2.32.38	3	128.2.67.221	3	2 07/31/2003
13:19:32	07/31/2003 13:19:45	Block_all							
9378	07/31/2003 13:20:49	Allowed	TCP	Outgoing	pgg.yahoo.com	66.163.175.128	80	128.2.67.221	1772 C:\Program
Files\Yahoo\Messenger\YPager.exe	1	07/31/2003 13:19:47	07/31/2003 13:19:47		Ask all running apps				
9379	07/31/2003 13:21:10	Blocked	UDP	Incoming	128.2.72.14	1044	128.2.79.255	138	C:\WINNT\System32\ntoskrnl.exe
3	07/31/2003 13:19:18	07/31/2003 13:20:07			GUI%GUICONFIG#SRULE@INBLOCK#BLOCK-UDP				
9380	07/31/2003 13:21:15	Blocked	UDP	Incoming	128.2.78.115	49169	128.2.79.255	2222	

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4.8.2 Analyzing Tiny Personal Firewall Log File Format

This is an example of Tiny Personal Firewall's⁷⁵ log, which is a tab delimited file. The format may change (tab, comma, or space delimited) but the content is representational of firewall logs. Firewall logs represent a wealth of information. This is where attempted attacks will present themselves (network scans, port scans, icmp scans, etc).

In addition to the firewall logs, most networks will run an intruder detection system (IDS) like Snort.⁷⁶ The IDS will send some type of notification to the administrator, most likely an email outlining an event. This event will include the IP address of the attacker or attempted intruder and a brief description of what occurred. It is very important to use this information, especially the IP address, to add additional access controls to the firewall, but that is not the only thing you should do. Now that the IP address has been blocked, it is useful to locate the event that was reported by the IDS system in the raw firewall logs. This is useful because it will be important to know whether the reported IP address was ever blocked or otherwise logged at the firewall.

This type of cross checking between log files is critical and can yield a lot of information about an attacker. For each significant IDS alert, you should try to discover when that attacker visited your network for the first time. Collecting information to establish a chronology of an IP address's (attacker's) history is a first step toward understanding what happened during an attack and how the attacker exploited the network security.

⁷⁵ For more information about Tiny Firewall see <http://www.tinysoftware.com>

⁷⁶ For more information about Snort see <http://www.Snort.org/>

Log File Analysis - 3

Most log files are saved as “flat files” and can be viewed with Notepad (delimited by spaces, commas, or tabs)

Exportable to programs like Excel and Access for analysis... **must establish a common interface**

Demo: Log File

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4.8.3 Exporting Data from Log Files

There are lots of high end vendor tools that will analyze your log files. Some do a really good job. But the purpose of this section is to teach you how to use freeware tools or commonly available tools to do the same job as the expensive high end tools.

Since most log files are flat files they can be dealt with in many different ways. It is important to note that although log files may be in the same general format, the order and fields will vary from log to log. This presents a problem because the files cannot just be exported—you must know what is being logged and be familiar with the fields (these are the options that are set when turning on logging).

One simple technique for examining a single log file is to look at the raw file using Microsoft Notepad. Most log files will open in the Notepad application. With practice, you should be able to identify security issues with this technique.

Using Notepad to Examine Log Files

1. From the Start menu, select Programs > Accessories > Notepad.
2. From the Edit menu in Notepad, select Find. The Notepad window and Find dialog are shown in Figure 67.
3. Enter an attacker’s IP address from the IDS notification and click the Find button. Notepad will search through the file and highlight the first occurrence of that IP address. You can continue to look for additional occurrences by clicking the Find Next button.

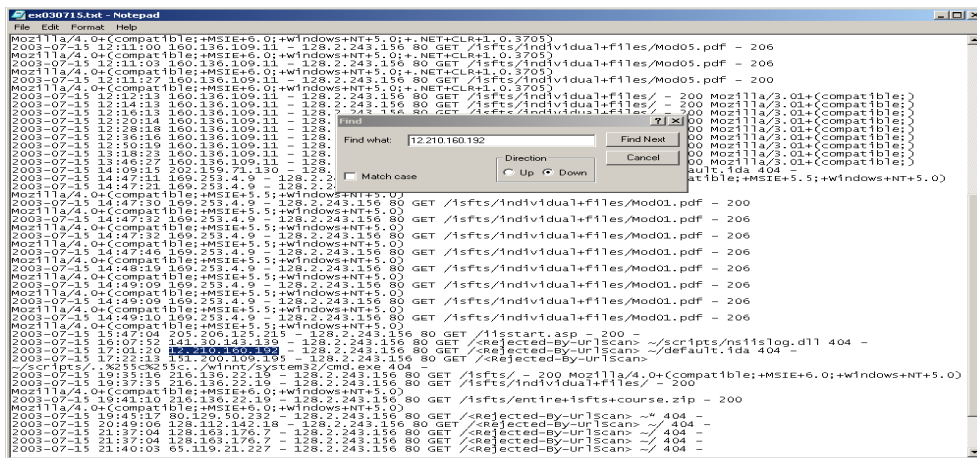


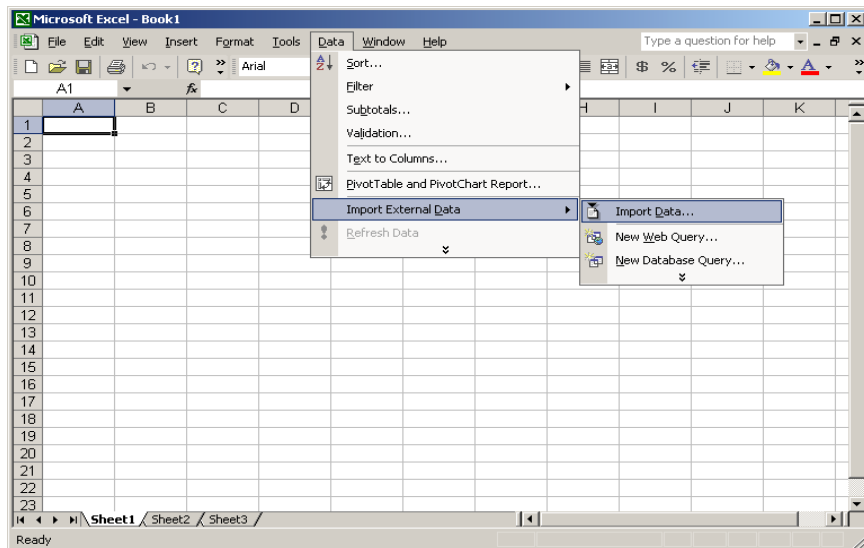
Figure 67: Microsoft Notepad

This is a quick and effective way of examining log files. The same Find command can search for a URL if you are searching ISS Log Files and are interested in seeing visitors to a specific URL. Notepad will also search for an alphanumeric string.

Another way of analyzing log files is to import them into a spreadsheet application like Microsoft Excel. Once in Excel, you can do a host of more complex searches as well as basic comparisons between multiple files (as long as they have the same fields).

Using Excel to View and Analyze Log Files

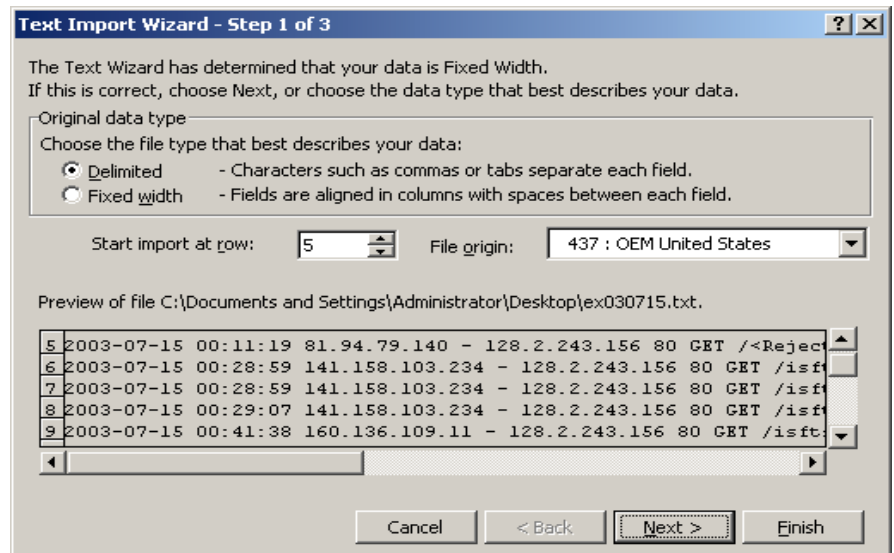
1. Once Excel is open, select Data > Import External Data > Import Data as shown in the screen at right. This will open a window where you must select the source file to import.



Once you have selected and imported the source file, the Text Import

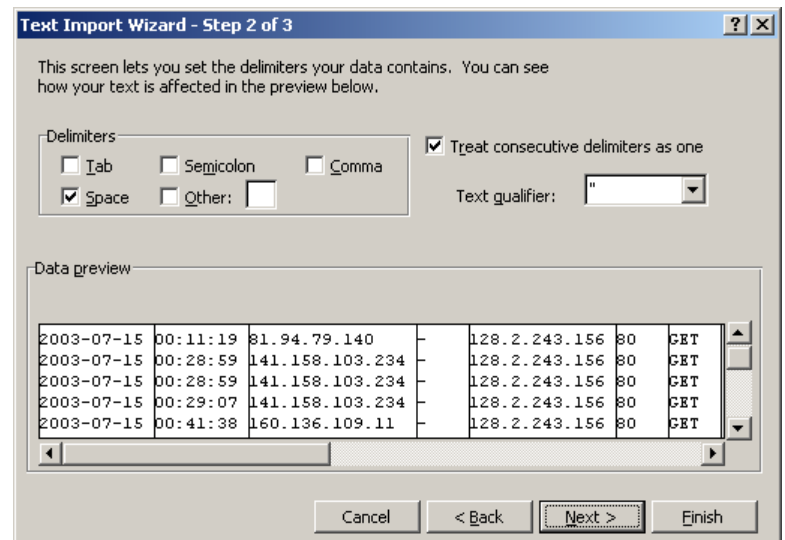
Wizard will appear. In this three step process, you will identify what type of file is being imported; allow for entry of field titles; and allow for adjustments to the imported file.

- The first step of the wizard is to determine what type of data is being imported. There are two choices: Delimited or Fixed width. Also, there is an option for what row on which to start importing. This is useful because most log files will have the field data, time stamps, and other information

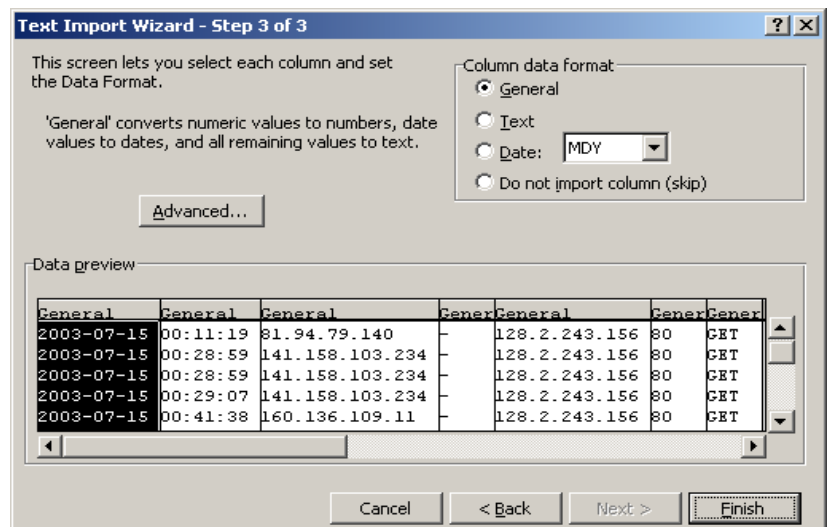


before the data begins. This option will allow for the non-related data to be excluded.

- Step two in the wizard will allow you to set the delimiters (Tab, Comma, or Space). When you choose one, a data preview will appear. Review it to ensure that you have chosen the correct delimiter. Make sure the fields are correctly displayed and the data is not split between columns. This is a very important step because if you select the delimiter incorrectly, the data will be unusable in the spreadsheet.

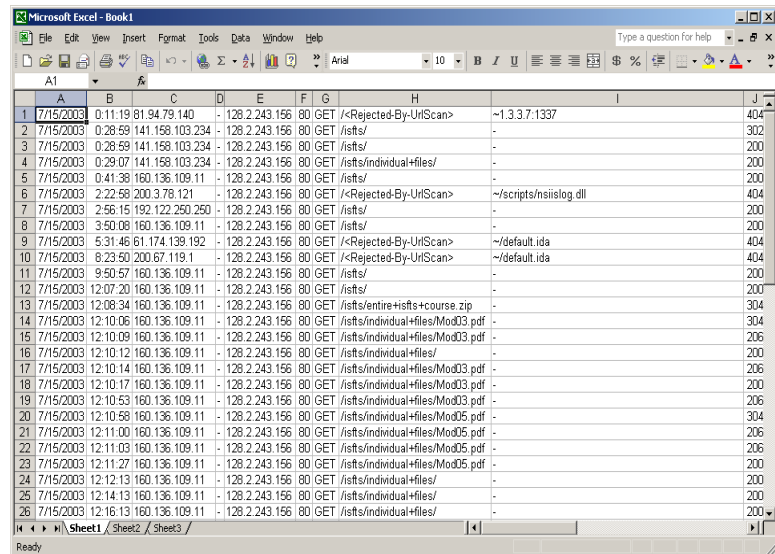


- Step three is another very important step, especially if you wish to import more than one log file. This screen will let you select the data format and field name for each of the columns in the spreadsheet. This means that you must identify what type of data is contained in each column. (Text, Data, Time, etc.) Also, you have the option to



eliminate columns that are not needed in the analysis. If you are importing two or more log files it is critical that the fields to be imported and data types be identical or cross comparing logs will be impossible.

- Now the log file data has been imported to Excel. In Excel a variety of searches can be conducted. Unlike the simple Find command in Notepad, Excel has many powerful features. It is possible to search in a time range, search an IP block, compare multiple logs, and determine common events. If you select Data > Filters, you will see the Auto Filter option. This feature will allow for a wide variety of preconfigured searches.



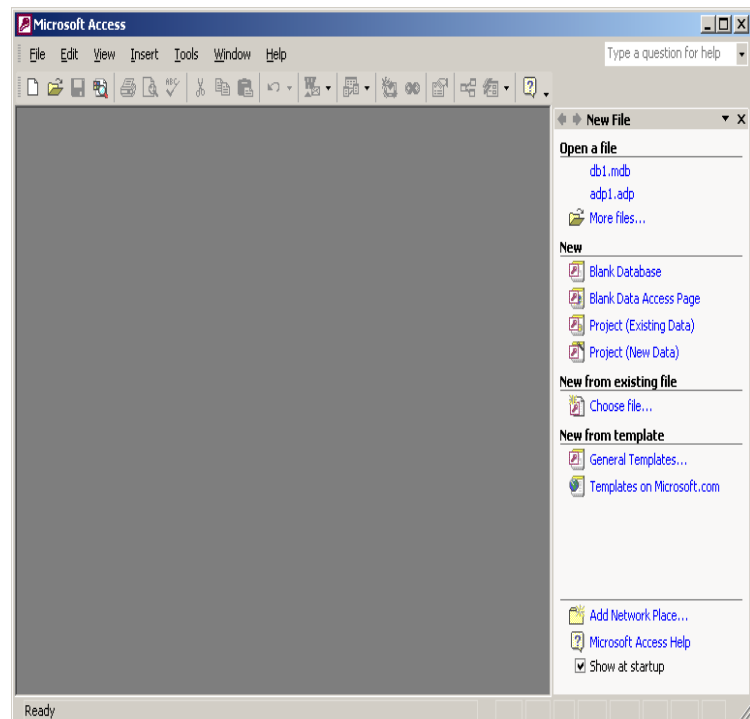
	A	B	C	D	E	F	G	H	I	J
1	7/15/2003	0.11.19	81.94.79.140	-	128.2.243.156	80	GET	/<Rejected-By-UriScan>	-1.3.3.7.1337	404
2	7/15/2003	0.28.69	141.158.103.234	-	128.2.243.156	80	GET	/ists/	-	302
3	7/15/2003	0.28.69	141.158.103.234	-	128.2.243.156	80	GET	/ists/	-	200
4	7/15/2003	0.29.07	141.158.103.234	-	128.2.243.156	80	GET	/ists/individual+files/	-	200
5	7/15/2003	0.41.38	160.136.109.11	-	128.2.243.156	80	GET	/ists/	-	200
6	7/15/2003	2.22.68	200.378.121	-	128.2.243.156	80	GET	/<Rejected-By-UriScan>	~/scripts/insislog.dll	404
7	7/15/2003	2.56.15	192.122.250.250	-	128.2.243.156	80	GET	/ists/	-	200
8	7/15/2003	3.50.08	160.136.109.11	-	128.2.243.156	80	GET	/ists/	-	200
9	7/15/2003	5.31.46	61.174.139.192	-	128.2.243.156	80	GET	/<Rejected-By-UriScan>	~/default.ida	404
10	7/15/2003	8.23.60	200.67.119.1	-	128.2.243.156	80	GET	/<Rejected-By-UriScan>	~/default.ida	404
11	7/15/2003	9.50.57	160.136.109.11	-	128.2.243.156	80	GET	/ists/	-	200
12	7/15/2003	12.07.20	160.136.109.11	-	128.2.243.156	80	GET	/ists/	-	200
13	7/15/2003	12.08.34	160.136.109.11	-	128.2.243.156	80	GET	/ists/entire+ists+course.zip	-	304
14	7/15/2003	12.10.06	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/Mod03.pdf	-	304
15	7/15/2003	12.10.09	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/Mod03.pdf	-	206
16	7/15/2003	12.10.12	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/	-	200
17	7/15/2003	12.10.14	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/Mod03.pdf	-	206
18	7/15/2003	12.10.17	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/Mod03.pdf	-	200
19	7/15/2003	12.10.53	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/Mod03.pdf	-	206
20	7/15/2003	12.10.58	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/Mod05.pdf	-	304
21	7/15/2003	12.11.00	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/Mod05.pdf	-	206
22	7/15/2003	12.11.03	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/Mod05.pdf	-	206
23	7/15/2003	12.11.27	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/Mod05.pdf	-	200
24	7/15/2003	12.12.13	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/	-	200
25	7/15/2003	12.14.13	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/	-	200
26	7/15/2003	12.16.13	160.136.109.11	-	128.2.243.156	80	GET	/ists/individual+files/	-	200

A third commonly available tool is a Microsoft Access database. Access is more powerful than Excel and is much better suited for handling numerous large log files simultaneously. Importing log files into Access is similar to Excel except that Access will treat each log file as a separate table, whereas Excel treats all the data as a single sheet.

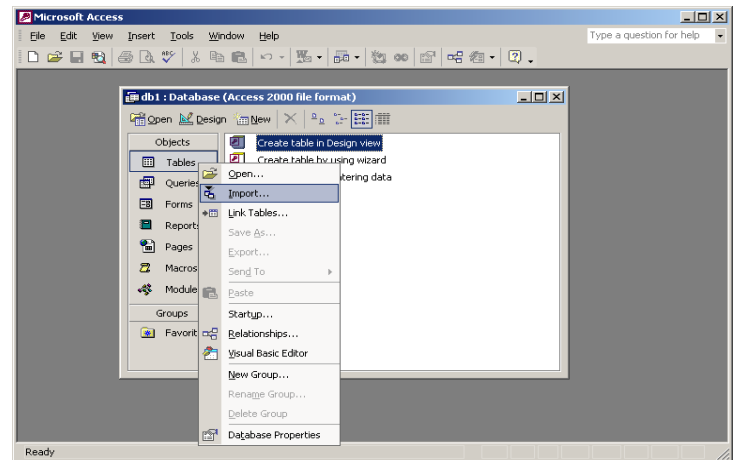
Using Access to View and Analyze Log Files

- Once Access is open, create a new database. Do this by clicking on the blank database icon and entering a name.

Remember to use common naming conventions so that when additional databases are created they can be related and easily understood. The name you choose will be a high level name for the location where several log files will be located.

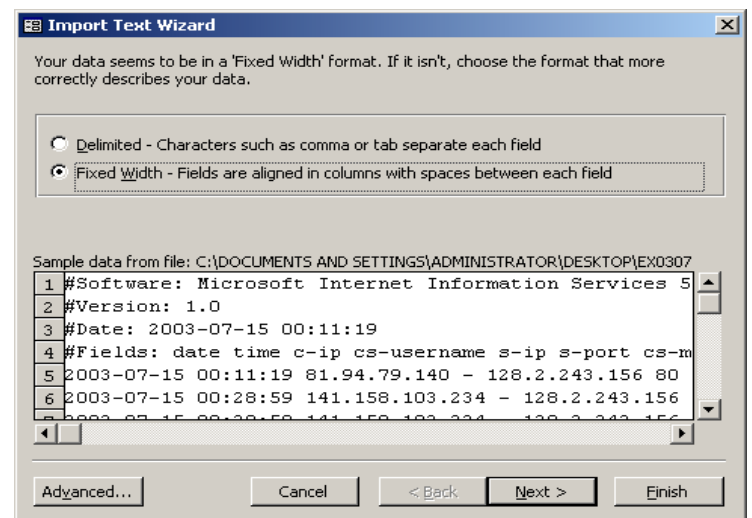


2. From the newly created database window, right click on the Table option under the Objects row. (In Access, the Table is a single data set like a log file from a firewall.)

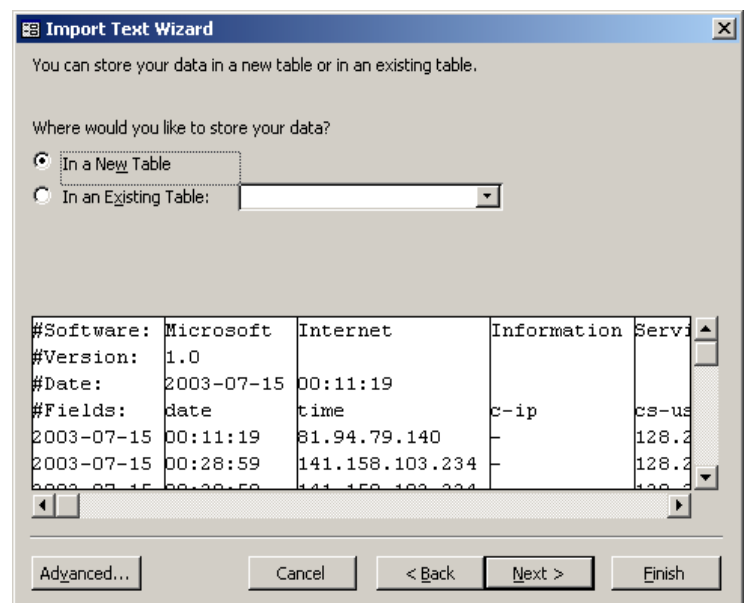


3. Select the Import option from the window. Once this is selected an Import Wizard Screen will appear and prompt for additional information.

4. Select the format of the data (log file) to be imported into Access. There are only two choices. There will be a window that displays the data using the selected setting, so make sure it is readable and clearly divided by fields. Otherwise, the table that is created to use this data will be useless.



5. Now that you have identified the format of the data to be imported, Access will ask you to name the table that will contain this data. Again, use a common naming convention so that the name will help you associate the table with the original log files.



6. This is a very important step. Access is prompting you to provide a field name for each of the imported columns. The names for these columns should be found in the original log file. The example at right shows a Windows ISS file. You can see the field identifiers in the data. When you import multiple log files this becomes more important. If Access is going to work correctly the data must have common fields with names that represent the same data.

Field Options

Field Name: Data Type:

Indexed: ☐ Do not import field (Skip)

Field1	Field2	Field3	Field4	Field5
#Software:	Microsoft	Internet	Information	Service
#Version:	1.0			
#Date:	2003-07-15	00:11:19		
#Fields:	date	time	c-ip	cs-us
2003-07-15	00:11:19	81.94.79.140	-	128.2
2003-07-15	00:28:59	141.158.103.234	-	128.2

Buttons: Advanced... Cancel < Back Next > Finish

7. Now Access asks you to identify a primary key to uniquely identify each record in the table. You should use the time stamp as your primary key. Since all of your files are time synchronized, Access will be able to compare and identify records using the time stamp.

Microsoft Access recommends that you define a primary key for your new table. A primary key is used to uniquely identify each record in your table. It allows you to retrieve data more quickly.

☒ Let Access add primary key.

☐ Choose my own primary key.

☐ No primary key.

ID	date	Field2	Field3	Field4
1	#Software:	Microsoft	Internet	Information
2	#Version:	1.0		
3	#Date:	2003-07-15	00:11:19	
4	#Fields:	date	time	c-ip
5	2003-07-15	00:11:19	81.94.79.140	
6	2003-07-15	00:28:59	141.158.103.234	

Buttons: Advanced... Cancel < Back Next > Finish

8. This is the final step for getting the log file data into Access. This last step is important. Access is asking what name to give to the table. This should be a name that will help you associate the table with the original file. Remember, you will need to repeat all eight steps for each individual log file to be entered.

That's all the information the wizard needs to import your data.

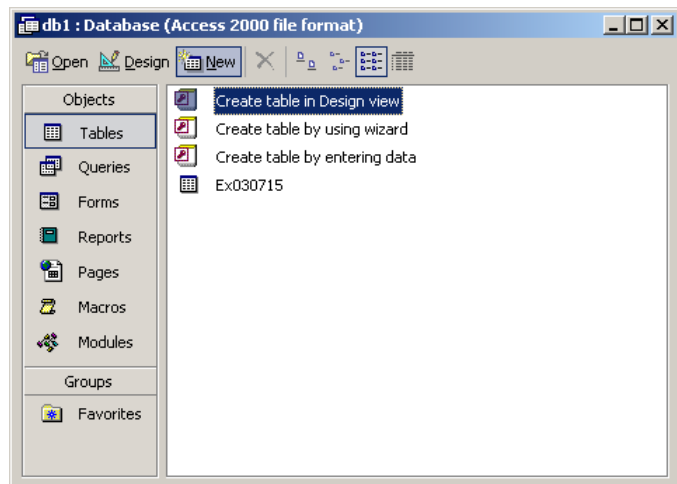
Import to Table:

☐ Display Help after the wizard is finished.

Buttons: Advanced... Cancel < Back Next > Finish

Access is not the tool to use for a single log file. For single files, use Excel or even Notepad. The real power of Access will be realized when numerous log files are entered.

It is a little time consuming, but if you plan to review log data on a weekly basis and you can enter the various log files that are collected, you can create a weekly database of that week's log files.



With multiple log files loaded into Access using the time as the primary key, an administrator can create a report that polls all log files for records from a particular moment in time or during a specified time period. This type of information is very important when attempting to collect information about an intrusion or when responding to an incident. With Access, you can create almost any kind of report imaginable. The specific type of report is dependant on what an administrator is trying to achieve. You can create reports for security events, to track peak usage times, or to identify the most common IP address to visit your network.



Log File Analysis - 4

Prioritize Log Reviews:

Known Vulnerabilities

- Port Scans
- Vulnerabilities Scans
- Outbound Attacks
- Hardware Failures
- Failed Log-in Attempts
- Modification of Security Files/Settings
- Configuration Changes

Unknown Events

- Unusual Patterns
- Unknown Error
- Unrecognized Events

Normal Activity

- Authorized Activities
- Scheduled Hardware
- Outages

4.8.4 Reviewing Log Files

Review is the most important aspect to logging and analysis. Unless a regular review is conducted, the logged data is useless. It is vital to allocate time for log review as for any other job responsibility. Reviews should not be an added responsibility for an already overloaded administrator.

Although there are several reasons to review log files, the most important is that it will help you understand what your network is doing. If you are not familiar with normal activity on your network, identifying unusual activity will be next to impossible. Try to divide the review process into sections: normal activity, attacks or security activity, and unknown activity [Bird 03]. Even within these sections, activities can be parsed into further categories.

As the administrator you should be aware of scheduled outages, upgrades, and authorized access to systems so that these events can be disregarded and not consume valuable review time. The majority of log file review should be directed to attack/security and unknown events. As for the attack/security events, there are basically two subdivisions: critical and noncritical.

A critical event is an unauthorized configuration change on a system or an authorized modification to a security setting. These types of activities require immediate attention and further in-depth investigation. A non-critical event could be a port or vulnerability scan, which are a concern but present no immediate threat. These scans should be noted and watched for in the future. Most of this type of activity are from automatic tools being run by people with little knowledge or ability; however, be aware that there are very bright people who spend a considerable amount of their time trying to compromise systems.

The unknown event category is probably going to be the area where you spend most of your review time. It is important to stay abreast of current security threats, newly posted advisories, and vulnerabilities. IDS signature may not be immediately available to protect your system. The CERT Web site at <http://www.cert.org> is a good location to check often for security threats and advisories.

4.9 Freeware Log and Forensic Tools and Applications

As for tools, in addition to using Notepad, Excel, and Access to review log files, there are hundreds available on the market. Remember, there is no one magical tool or application that does it all. No matter how advanced the tools are they will always require the interaction of an informed administrator to make substantive decisions. Below is an overview of some of the better known freeware log and forensic tools and applications:⁷⁷

Table 7: Freeware Log and Forensic Tools and Applications

Tools that report systems events	
Examples of tools that monitor and inspect for use of system resources (e.g., changes to file systems) and suspicious activity (e.g., unusual or unexpected open files, successful and failed administrative logins, unexpected shutdowns and restarts, unusual modem activities, unusual or excessive email activities).	<ul style="list-style-type: none"> • watcher ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/watcher/ • klaxon ftp://ftp.cerias.purdue.edu/pub/tools/unix/logutils/klaxon/ • lsof (LiSt Open Files) http://www.cert.org/security-improvement/implementations/i042.05.html • nfswatch ftp://ftp.cerias.purdue.edu/pub/tools/unix/netutils/nfswatch/ • showid ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/showid/ • loginlog ftp://ftp.cerias.purdue.edu/pub/tools/unix/logutils/loginlog/
Examples of active intrusion detection systems, including active log file monitoring, that detect possible intrusions or access violations while they are occurring.	<ul style="list-style-type: none"> • Snort http://www.Snort.org/ • asax (Advanced Security audit trail Analysis on uniX) ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/asax/ • swatch http://www.cert.org/security-improvement/implementations/i042.01.html • logsurfer http://www.cert.org/security-improvement/implementations/i042.02.html • tklogger ftp://ftp.eng.auburn.edu/pub/doug/tklogger
Tools that report network events	

⁷⁷ <http://www.cert.org/security-improvement/implementations/i042.07.html>

Examples of tools that monitor and inspect network traffic and connections (e.g., what kinds of connections, from where, and when) both for attempted connections that failed as well as for established connections, connections to/from unusual locations, unauthorized network probes, systematic port scans, traffic contrary to your firewall setup, and unusual file transfer activity.	<ul style="list-style-type: none"> • tcp wrapper http://www.cert.org/security-improvement/implementations/i041.07.html • tcpdump http://www.cert.org/security-improvement/implementations/i042.13.html • argus http://www.cert.org/security-improvement/implementations/i042.09.html • arpmon ftp://ftp.cerias.purdue.edu/pub/tools/unix/netutils/arpmon/ • arpwatch ftp://ftp.cerias.purdue.edu/pub/tools/unix/netutils/arpwatch/ • Snort http://www.Snort.org/ • courtney ftp://ftp.cert.dfn.de/pub/tools/audit/courtney/ • gabriel ftp://ftp.cert.dfn.de/pub/tools/audit/gabriel/ • logdaemon http://www.cert.org/security-improvement/implementations/i041.11.html • rfingerd ftp://ftp.cerias.purdue.edu/pub/tools/unix/daemons/rfingerd/ • clog ftp://ftp.cerias.purdue.edu/pub/tools/unix/logutils/clog/ • pidentd ftp://ftp.cert.dfn.de/pub/tools/audit/pidentd/ • enhanced portmap/rpcbind ftp://ftp.porcupine.org/pub/security/
Examples of tools that detect whether your network interface card is in promiscuous mode.	<ul style="list-style-type: none"> • ifstatus ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/ifstatus/ • cpm (Check Promiscuous Mode) ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/cpm/
Examples of tools that detect new, unexpected services and verify the expected, available services on your network.	<ul style="list-style-type: none"> • nmap http://www.insecure.org/nmap • fremont ftp://ftp.cerias.purdue.edu/pub/tools/unix/netutils/fremont/ • strobe ftp://ftp.cerias.purdue.edu/pub/tools/unix/scanners/strobe/ • iss (Internet Security Scanner) ftp://ftp.cerias.purdue.edu/pub/tools/unix/scanners/iss/ • satan (System Administrator Tool for Analyzing Networks) ftp://ftp.porcupine.org/pub/security/ • saint (Security Administrator's Integrated Network Tool) http://www.wdsi.com/saint • sara (Security Auditor's Research Assistant) http://www.www-arc.com/sara/
Tools that report user-related events	
Examples of tools that check	<ul style="list-style-type: none"> • cops (Computer Oracle and Password System)

account configurations, such as authentication and authorization information.	ftp://ftp.cerias.purdue.edu/pub/tools/unix/scanners/cops/ <ul style="list-style-type: none"> • tiger ftp://ftp.cerias.purdue.edu/pub/tools/unix/scanners/tiger/ • checkXusers http://www.rge.com/pub/security/coast/tools/unix/sysutils/checkXusers/checkXusers.gz • chkacct ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/chkacct/
Examples of tools that monitor and inspect user activity, such as login activity, repeated, failed login attempts, logins from unusual locations, logins at unusual times, changes in user identity, unauthorized attempts to access restricted information, etc.	<ul style="list-style-type: none"> • noshell ftp://ftp.cerias.purdue.edu/pub/tools/unix/ • ttymatcher ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/ttymatcher/ • logdaemon http://www.cert.org/security-improvement/implementations/i041.10.html
Tools that verify data, file, and software integrity	
Examples of tools that inspect operating systems and tool configurations for possible signs of exploits, such as improperly set access control lists on system tools, etc.	<ul style="list-style-type: none"> • cops ftp://ftp.cerias.purdue.edu/pub/tools/unix/scanners/cops/ • tiger ftp://ftp.cerias.purdue.edu/pub/tools/unix/scanners/tiger/ • secure-sun-check ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/secure_sun/
Examples of tools that detect unexpected changes to the contents or protections of files and directories..	<ul style="list-style-type: none"> • tripwire http://www.cert.org/security-improvement/implementations/i002.02.html • L5 ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/l5/ • hobgoblin ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/hobgoblin/ • RIACS (Research Institute for Advanced Computer Science) Auditing Package http://ciac.llnl.gov/ciac/ToolsUnixSysMon.html#Riacs
An example of a tool that scans for Trojan horses.	<ul style="list-style-type: none"> • trojan.pl ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/trojan/
Tools to examine your systems in detail, periodically or as events warrant	
Examples of tools that reduce and scan log files to enhance the immediate detection of unusual activity.	<ul style="list-style-type: none"> • top http://www.cert.org/security-improvement/implementations/i042.06.html • sps (Special Process Status) http://www.cert.org/security-improvement/implementations/i005.03.html • spar (Show Process Accounting Records) http://www.cert.org/security-improvement/implementations/i042.04.html • logcheck

	ftp://ftp.cerias.purdue.edu/pub/tools/unix/logutils/logcheck/
Examples of tools that check log consistency for possible tampering	<ul style="list-style-type: none"> • chklastlog ftp://ftp.cerias.purdue.edu/pub/tools/unix/logutils/chklastlog/ • chkwtmp ftp://ftp.cerias.purdue.edu/pub/tools/unix/logutils/chkwtmp/ • loginlog ftp://ftp.cerias.purdue.edu/pub/tools/unix/logutils/loginlog/ • trimlog ftp://ftp.cerias.purdue.edu/pub/tools/unix/logutils/trimlog/
Examples of tools that check for known vulnerabilities	<ul style="list-style-type: none"> • nessus http://www.nessus.org/ • satan (System Administrator Tool for Analyzing Networks) ftp://ftp.porcupine.org/pub/security/ • saint (Security Administrator's Integrated Network Tool) http://www.wwdsi.com/saint • sara (Security Auditor's Research Assistant) http://www.www-arc.com/sara/ • iss (Internet Security Scanner) ftp://ftp.cerias.purdue.edu/pub/tools/unix/scanners/iss/ • tiger ftp://ftp.cerias.purdue.edu/pub/tools/unix/scanners/tiger/
An example of a tool set that helps you conduct forensic analysis	<ul style="list-style-type: none"> • TCT (The Coroner's Toolkit) http://www.fish.com/forensics/

Identifying Attackers (Intranet)

Determine target IP address, query DHCP/IP table for Mac address

Check the Arp table and copy the log

Query the packet sniffer for traffic with target IP address and trace activities via the packet capture

Establish timeline of activities

4.10 Identifying Attackers on Your Intranet

Considering that 70% of network intrusions and attacks occur from internal hosts, it's a shame that corporate America spends about 70% of its network security efforts on detecting and protecting against external security threats [Bird 03]. Given this statistic, network administrators should become more aware of network tools and techniques to monitor internal activity and identify host/users that violate internal policies and, more importantly, exceed their access privileges

From an investigatory perspective, it is far easier to track and identify an intranet user who causes harm or violates access rights than it is to track and identify an external host who attacks from the Internet. A few very simple implementations, in addition to the diligent review of log files, can greatly enhance an administrator's monitoring ability:

1. Ensure that the DHCP tables are logged. If a static table is used, make sure that it is securely maintained.
2. Incorporate arpwatch⁷⁸ into the user network. Arpwatch is an application that monitors IP/MAC address pairing and can notify you via email when a pairing has changed. A change in pairing is an excellent indicator that a user is up to no good.
3. Install a packet capture system on your services network. This will enable the tracking and identification of users who are accessing services. (Prior to installing a packet capture device, ensure that it is consistent with current IT policies and approved by your

⁷⁸ <http://www.securityfocus.com/tools/142>

legal department.) As a best practice, you should also post a banner on all systems informing users that they are subject to monitoring.

With just a few additions to network infrastructure, you can take advantage of enormous amounts of information that will help you track and identify intranet users who exceed access privileges or violate policies.

When attempting to investigate an internal violation, the first step is to identify the IP address in question and create a chronology of activity by reviewing the log files and packet capture data for the security event. Once you are sure of the IP address that is the source for the event, it is easy to determine whether it's an internally assigned IP address. Next, check the DHCP server for the table that will translate the target IP address to the MAC address of the NIC card that is connected to the source host. At this point, you should check the arpwatch logs to verify that the MAC address was not spoofed. Depending on the nature and severity of the security event, you may now want to consider forensically examining the hard drive of this system. The final step should be to gather the user's old IP addresses from the DHCP logs and then search the system logs from the corresponding time period to check for other non-alerted illegal or unauthorized activities.

Identifying Attackers' IP Addresses

Determine what happened and what the attacking IP address is or was.

Block this source. Check archived and current logs for this address and attempt to identify the OS, system configuration, and history of contact.

Sample IIS Log Entry:

```
2003-07-15 12:07:20 160.136.109.11 - 128.2.243.156 80 GET /sfts/- 200
Mozilla/4.0+(compatible;+MSIE+6.0;+Windows+NT+5.0;+.NET+CLR+1.0.3705)
2003-07-15 12:08:34 160.136.109.11 - 128.2.243.156 80 GET
/sfts/entire+isfts+course.zip - 304
2003-07-15 12:10:06 160.136.109.11 - 128.2.243.156 80 GET
/sfts/individual+files/Mod03.pdf - 304
2003-07-15 12:10:09 160.136.109.11 - 128.2.243.156 80 GET
/sfts/individual+files/Mod03.pdf - 206
```

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4.11 Identifying Attackers' IP Addresses

In a review of your log files, you notice that one IP address is attempting to log on to your system repeatedly and is also conducting port and vulnerability scans. Naturally, your first step is to block this IP address at the firewall, but you should also investigate what it did and where it went when it had access to your network.

4.11.1 Investigating the IP Address's History on Your Network

First, you should query the network logs to create a chronology and retrace the target IP address as it traversed your network. If you have your log files loaded into an access database, this will be very easy. All you will need to do is create a report that collects all records containing the target IP address. This will poll all the various log files (IDS, firewall, Web server, email server, etc.) and gather a list reflecting the history of that IP address within your network.

Another trick is to look at the Web logs. If turned on, Microsoft ISS logs can record some very useful information. Within the various logging fields of the ISS format there are three that will be very useful when trying to determine when an IP address first visited and whether that host system visited again from a different IP address:

- C-IP (the client IP address)
- SC-Status (a numerical code that identifies the connection status)
- User-Agent (the browser configuration of the client system)

C-IP

We discussed several ways to use the client IP address to identify attackers in Section 4.8.1.

SC-Status

You can attempt to determine the first time an IP address logged into your Web server by looking at the log files chronologically. You could also determine the same thing using the SC-Status. The first time an IP address visits your Web site, your server and the client will cache information. This will cause the SC-Status field to generate a “200” message.⁷⁹ This will only occur the first time a host system (browser) visits the site. So if you find the target IP address with the SC-Status message of 200, this will likely indicate first contact—the first time that the host browser using the target IP address visited the site.

User-Agent

The next useful technique is to look for User-Agent configurations. There will certainly be identical configurations, but you should attempt to discover whether your target IP’s host system visited the site using a different IP address. To do this, look at the User-Agent and SC-Status fields and try to identify IP addresses that have visited with no initial connection message of 200. This will be a good indicator of an intruder attempting to visit multiple times using different IP addresses from the same host browser [Burnett 03].

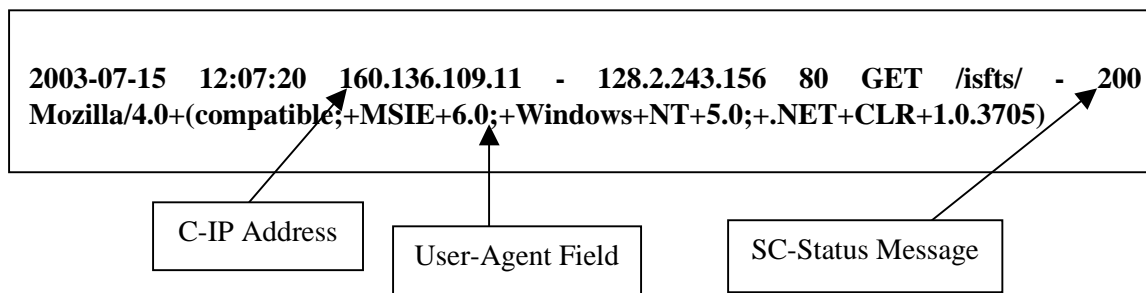


Figure 68: IIS Log Showing C-IP Address, User-Agent Field, and SC-Status

Remember, there is no single process or magic technique. Reviewing log files and security events is a dynamic process that will involve a multitude of tools and techniques and lots of creative thinking.

Now that you’ve identified what an IP address/attacker/intruder has done to your network, it’s time to try to identify the user (or at least the service provider that hosted the target IP address).

⁷⁹ For a complete listing of SC-Status messages, see http://www.microsoft.com/technet/treeview/default.asp?url=/technet/prodtechnol/windowsserver2003/proddocs/standard/cerr_aboutcusterr.asp

Identifying Attackers' IP Addresses - 2

Enumerate the target: collect publicly available information (always use a proxy or anonymizer)

nslookup/dig	IP Look-up on the IP address from its domain name server
Whois	Ascertain the IP ownership and/or the attacking IP's network. Look at the NetBlock assignment (<i>Query that NetBlock against log files</i>)
Traceroute	Identify the up-stream provider and location of physical host
Who is upstream provider?	Determine "acceptable use policy;" follow up with upstream provider by contacting the abuse department and reporting to authorities.

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4.11.2 Enumerating the Target with Network Tools

There are many network tools that can be used to gather information about the ownership, location, association, etc. of an IP address. (When trying to gather information about an IP address, always use an anonymizer service.⁸⁰ This will ensure that the attacker/intruder will not see your IP address while you are conducting these information gathering services.) The following are three very useful tools that can provide a wealth of information about (a) the identity of an attacker/intruder or (b) the owner/upstream provider that controls the IP address.

Nslookup/dig – This tool allows a user to look up a domain name or host name to resolve the IP address or look up an IP address to resolve the host name of a network node.

Whois – The whois utility obtains information about a Internet host or domain name. Whois can be used to identify vital information such as owner, administrator, and technical contact about a domain name.

Traceroute – The Traceroute utility can identify all the “hops” a network packet will take to get from the host machine to the destination machine. Traceroute can be used to diagnose network problems and identify the cost of each network hop in terms of time.

All three of these are command line tools but have also been ported to GUI interface sites. For now, let's just talk about the function and type of information obtainable using these tools.

⁸⁰ <http://www.anonymizer.com/> is a free site that will provide basic service.

NSlookup

Nslookup is a very useful tool when trying to identify a domain or network to which an IP address belongs. An example of this would be if you attempted an nslookup on IP address 128.2.65.189. You would learn that the IP address (128.2.65.189) resolved to the DNS server DESAIX.WV.CC.cmu.edu. This is very useful information: you may have just identified the network from which this IP address originated.

The next step is to try to discover information about the domain you identified (CMU.EDU). A “whois” search will gather information from the DNS records: administrative contact, technical contact, telephone numbers, addresses, NS server(s), and the date the domain name was registered. If you conducted a “whois” on CMU.EDU, you would see the following:

Domain Name: CMU.EDU
Registrant: Carnegie-Mellon University Computing Services 5000 Forbes Avenue Pittsburgh, PA 15213 UNITED STATES
Contacts: Administrative Contact: Mark Poepping Carnegie Mellon University 5000 Forbes Ave Pittsburgh, PA 15213-3890 UNITED STATES (412) 268-6722 poepping@cmu.edu
Technical Contact: CMU Host Master Carnegie Mellon University Cyert Hall - Second Floor 5000 Forbes Ave Pittsburgh, PA 15213-3890 UNITED STATES (412) 268-6110 host-master@andrew.cmu.edu
Name Servers: T-NS1.NET.CMU.EDU 128.2.4.14 T-NS2.NET.CMU.EDU 128.2.11.151 CUCUMBER.SRV.CS.CMU.EDU 128.2.206.130
Domain record activated: 24-Apr-1985 Domain record last updated: 19-Aug-2002

Figure 69: A "Whois" Search on the Domain CMU.EDU

Now you have contact names, email addresses, and telephone numbers for the owners of the domain name to which the target IP resolved. At this point you might want to look at the Web site for this domain, find its acceptable use policy, and see if the target IP address violated the policy by attacking/intruding into your network. Chances are pretty good that it did. Now you can consider contacting the administrative contact person for the domain to report the situation.

Reverse IP Lookup

Let's suppose that the nslookup did not resolve the IP address to a DNS server. At this point you have to do a reverse IP lookup to see who owns the IP address. This can be done at a number of sites. The American Registry for Internet Numbers (ARIN) provides a good reverse IP lookup on its home page at <http://www.arin.net/>. If you enter 128.2.65.89 in the reverse look-up box, the search will return the following information:

```
08/06/03 13:31:13 IP block cmu.edu
Trying 128.2.11.43 at ARIN
Trying 128.2.11 at ARIN

OrgName:      Carnegie Mellon University
OrgID:        CARNEG
Address:       Computing Services
Address:       5000 Forbes Avenue
City:         Pittsburgh
StateProv:    PA
PostalCode:   15213
Country:      US

NetRange:     128.2.0.0 - 128.2.255.255
CIDR:         128.2.0.0/16
NetName:      CMU-NET
NetHandle:    NET-128-2-0-0-1
Parent:       NET-128-0-0-0-0
NetType:      Direct Assignment
NameServer:   T-NS1.NET.CMU.EDU
NameServer:   T-NS2.NET.CMU.EDU
NameServer:   CUCUMBER.SRV.CS.CMU.EDU
Comment:
RegDate:
Updated:      2002-08-20

TechHandle:   CH4-ORG-ARIN
TechName:     Carnegie Mellon Hostmaster
TechPhone:    +1-412-268-2638
TechEmail:    host-master@andrew.cmu.edu

OrgAbuseHandle: CMA3-ARIN
OrgAbuseName:   Carnegie Mellon Abuse
OrgAbusePhone:  +1-412-268-4357
OrgAbuseEmail:  abuse@andrew.cmu.edu

OrgTechHandle: CH4-ORG-ARIN
OrgTechName:   Carnegie Mellon Hostmaster
OrgTechPhone:  +1-412-268-2638
OrgTechEmail:  host-master@andrew.cmu.edu
```

Figure 70: Reverse IP Lookup on an IP Address

This type of search yields information that is very similar to that obtained with nslookup. Nevertheless, you now have lots of contact information to use if you decide to report the intruder's IP address and actions.

Traceroute

The last tool we are going to talk about is traceroute. A traceroute will identify all the hops that are required to reach the target IP address. What is most useful about this is that the next to last hop before reaching the target is likely to be the upstream provider to the IP address. Also, you can probably get a general idea of the physical location of the target IP address from the last few hops. Figure 71 shows what you would see if you did a traceroute on 128.2.65.89.

3	130.152.180.21	11.351 ms	isi-1-lngw2-atm.ln.net [AS226] Los Nettos origin AS
4	198.172.117.161	9.784 ms	ge-2-3-0.a02.lsanca02.us.ra.verio.net (Fake rDNS) [AS2914] Verio
5	129.250.46.94	10.573 ms	ge-3-3-0.a02.lsanca02.us.ra.verio.net [AS2914] Verio
6	129.250.29.136	15.868 ms	xe-1-0-0-4.r21.lsanca01.us.bb.verio.net [AS2914] Verio
7	129.250.2.187	17.136 ms	p16-1-1-0.r21.snjsca04.us.bb.verio.net [AS2914] Verio
8	129.250.2.72	13.520 ms	xe-0-2-0.r20.snjsca04.us.bb.verio.net [AS2914] Verio
9	129.250.2.70	12.000 ms	p64-0-0-0.r20.plalca01.us.bb.verio.net [AS2914] Verio
10	129.250.2.193	84.867 ms	p16-5-0-0.r02.mclnva02.us.bb.verio.net [AS2914] Verio
11	129.250.16.91	79.985 ms	p4-0-0-0.a01.pitbpa05.us.ra.verio.net [AS2914] Verio
12	199.239.216.14	76.796 ms	pos4-1-1-0.a01.pitbpa05.us.ce.verio.net [AS2914] Verio
13	192.88.115.1	78.337 ms	bar.psc.net [AS5050] NCNE GigaPoP Transit AS
14	192.88.115.182	89.488 ms	cmu-i1.psc.net [AS5050] NCNE GigaPoP Transit AS
15	128.2.33.226	92.708 ms	CORE0-VL501.GW.CMU.NET [AS9] Carnegie Mellon University Backbone AS
16	128.2.0.13	90.789 ms	CYH-VL1000.GW.CMU.NET [AS9] Carnegie Mellon University Backbone AS
17	*		

Figure 71: Traceroute Showing “Hops” Required to Reach Target IP Address

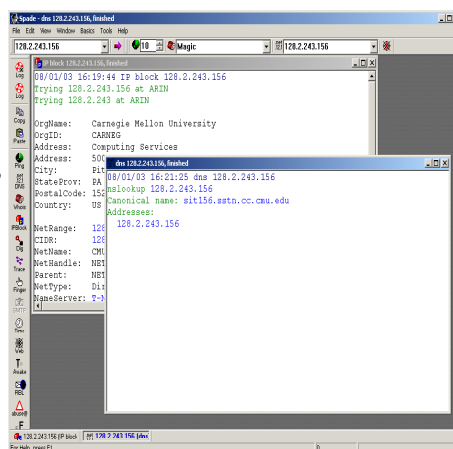
Based on the traceroute we can see that after 16 hops, the traceroute was no longer able to reach the target IP address. There was probably some sort of firewall or NAT happening. But we can still see that the target IP is part of the CMU network, and with this information we can look at the cmu.net domain name and gather more information.

These few tools are very common and frequently used. The examples here were very simple and easy to resolve. As you might imagine, this will not always be the case. Attackers will often spoof their IP addresses, use a relay service, or use an anonymizer. These techniques will all make identifying the source of an IP address more difficult. But with careful log file analysis and good forensic techniques, you stand a fair chance of at least identifying the network from which the attack or intrusion was launched.

Identifying Attackers' IP Addresses - 3

The Web site www.SamSpade.org offers a host of services essential to enumerating attackers' IP addresses.

A freeware desktop application is also available.



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Sam Spade Desktop

All the tools mentioned in Section 4.11.1 and a few more are available in an easy to use GUI interface known as Sam Spade Desktop.⁸¹ This will run from your desktop and allow a quick interface with a host of tools. The desktop version will not work as an anonymizer. For that feature, use the service on the Sam Spade Web site, which offers the same tools but will not link to your host IP address as the desktop application does.

⁸¹ The desktop tool is available for download at <http://www.samspade.org>.

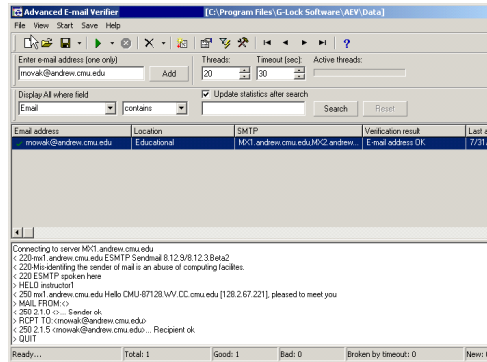
Identifying Attackers' Email Addresses

Copy source message and examine the header (full header, as opposed to the standard email header). Determine whether email was spoofed.

Conduct a "who is" query for the domain name and ensure that that IP address is within NetBlock.

Determine whether email is an active account.

Verify first valid "Received" field.



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4.11.3 Examining Email Addresses

Two things are essential in examining email addresses: how to determine whether an email is spoofed and identifying the sender's IP address.

A quick check of the full message header is enough to determine whether an email address has been spoofed. By default, most email programs like Mulberry and Outlook will show the short header message which includes the header lines containing From, To, Subject, Date, and CC information. It is easy to manipulate the "From" line that is shown in the short header, so you need to discover how to expose the full header message which contains much more reliable information. Figure 72 shows an example of a full header message from an email. (For instructional purposes, several additional "Received" message lines have been removed.)

```
Return-Path: <rnowak@andrew.cmu.edu>
Received: from (rnowak@>.andrew.cmu.edu [128.2.10.86]) by
beniaminus.red.cert.org [8.11.6/8.11.6/1.13] with ESMTTP id
h6VDJSv22069 for <ran@cert.org>; Thu, 31 Jul 2003 09:19:28 -0400
From: "Rob Nowak" <rnowak@>.andrew.cmu.edu
To: "'Richard Nolan'" <ran@cert.org>
Subject: RE: 2 questions
Date: Thu, 31 Jul 2003 09:19:26 -0400
```

Sender's SMTP domain not reliable;
may be just a relay or spoofed

Sender's email address
can be changed easily

Sender's IP address
most reliable.

Figure 72: Spoofed Email Header

In this example, to be relatively sure that `rnowak@andrew.cmu.edu` really sent the message, we can check a few things in the header. First, we want to see whether the sender's address in the From line of the message is the same as the sender's address that appears in the Received line. This alone does not verify that `rnowak@andrew.cmu.edu` is a good email address—the information in this line is easy to change—but this is the first, most obvious thing to check. The last thing and the most reliable is to do a `nslookup` on the sender's IP address to make sure that it resolves back to the same domain that is in the email address of the sender.

Once you verify that, it is reasonably safe to assume that the email is really from the sender. At this point, now that you know the sender's IP address, you can apply the same tools mentioned already to enumerate and further identify the sender (Sam Spade, etc.).

This is a basic overview of how to look at email headers. If you are interested in additional information, the site at <http://www.uic.edu/depts/accc/newsletter/adn29/headers.html> is very informative. The following RFCs also provide a lot of in-depth information:

- RFC 821 – SMTP
- RFC 974 – Mail Routing and the Domain System
- RFC 1049 – A Content Type Header Field for Internet Messages



Summary

Syslogging is a powerful network monitoring security tool

Time synchronization is fundamental to operations and security

Review log files; know what is normal and be able to recognize abnormal events

Take the time to investigate intruders and attempt to report violations to upstream providers

4.12 Summary



Review Questions

1. What is the basic difference between Syslogd and Syslog-ng?
2. What port is NTP assigned?
3. What is the first step when obtaining information about an intruder or IP address?
4. What common desktop applications can be used to view and conduct a simple log file analysis?

4.13 Review Questions

1. What is the basic difference between syslogd and syslog-ng?
2. What port is NTP assigned?
3. What is the first step when obtaining information about an intruder or IP Address?
4. What common desktop applications can be used to view and conduct simple log file analysis?

Answers to Review Questions

Module 1

1. The following are three host system hardening concepts:
 - Minimizing host system services, applications, and components/features
 - Isolating services from each other; best to have one service (e.g., Web server) per host
 - Configure host systems for logging/auditing, thereby ensuring accountability
2. IIS Lockdown Wizard and URLScan security templates can help harden a Windows IIS Web Server.
3. Group Policy can help secure a Windows 2000 domain by allowing administrators to centrally configure security settings and other policies that affect domain users and computers in a very granular manner.
4. The directory that should be inspected to see which services are loaded on a Red Hat Linux system is `/etc/rc.d`.
5. When administering rules on a host-based firewall, explicitly permit traffic destined to the specific services provided by the host. Deny all other traffic and log for matches against these rules.

Module 2

1. Ingress filtering consists of blocking packets destined for the internal network from the external network with a SOURCE address on the internal network (i.e. packets which must have a spoofed source address). Egress filtering blocks packets destined for the external network from the internal network with a SOURCE address which is not on the internal network (as well as packets which must have a spoofed source address).
2. Stateless packet filters can make filtering decisions based on the following characteristics of TCP packets: source TCP port, destination TCP port, TCP flags (SYN, ACK, RST, FIN, URG, PSH), TCP option number, source IP address, destination IP address.
3. The network services that fit best in a DMZ are those which must be made available to users on the Internet (or other untrusted network).
4. The following CHAINS are in the IPTables firewall suite:
 - a. Input Chain – handles traffic destined for firewall
 - b. Output Chain – handles traffic from firewall
 - c. Forward Chain – handles traffic which crosses FW
 - d. Prerouting Chain – destination NAT operations
 - e. Postrouting Chain – source NAT and masquerade operations

5. A rule that calls the LOG chain (which is built into IPTables) will log packets to `/var/log/messages` by default.

Module 3

1. Snort is a network-based, signature-based, open source IDS.
2. Here are four IDS deployment problems and solutions:
 - *Problem:* IDS is having trouble collecting all the packets on a network.
Solution: Use faster hardware/software, and/or tune the rule set and preprocessors.
 - *Problem:* Keeping IDS signature data up-to-date.
Solution: Check periodically for updates to new attacks and/or enable automatic updates.
 - *Problem:* Understanding the vast number of protocols on a network and making sure that your IDS is properly configured and optimized for the protocols you are likely to encounter on your network.
Solution: IDS can only collect data on a single network segment/collision domain. Use multiple IDS or multiple NICs in your IDS.
 - *Problem:* IDS can be attacked by intruders.
Solution: The machine that is running the IDS software needs to be hardened and administrators should use stealth IP addressing.
3. “Stealth” IP addressing is using a blank IP address or an IP address that is not routable over your network. On Linux systems, you can configure NICs to have a blank IP address value. On Windows host you can edit the registry to use 0.0.0.0 instead of the default IP value (i.e., 169.254.xxx.xxx).
4. Stealth IDS deployment is important because it allows you to hide your exposed IDS interface as a means to prevent users from attacking the host computer.
5. Out of the box, Snort is configured to detect more than 1200 types of potential attacks which include many types of scans and attacks you may never encounter because of the configuration of your network. Having Snort process all these rules can have adverse effects on the performance of your sensor.

Module 4

1. The basic difference between syslogd and syslog-ng is that syslog-ng is capable of TCP Transport rather than syslogd’s UDP. Syslog-ng also offers much more granular controls.
2. NTP is assigned to port 123.
3. The first step when obtaining information about an intruder or IP address is to use an anonymizer service.
4. Common desktop applications that can be used to view and conduct simple log file analysis are Notepad, Excel, and Access.

Resources

The following is a list of software, plug-ins, and other resources mentioned in the preceding modules. Most (if not all) of these items are free and available for download.

URLs are valid as of the publication date of this document.

Analysis Console for Intrusion Databases (ACID)	<http://www.cert.org/kb/acid>
argus	<http://www.cert.org/security-improvement/implementations/i042.09.html>
arpmon	<ftp://ftp.cerias.purdue.edu/pub/tools/unix/netutils/arpmon/>
arpwatch	<ftp://ftp.cerias.purdue.edu/pub/tools/unix/netutils/arpwatch/> <http://www.securityfocus.com/tools/142>
asax (Advanced Security audit trail Analysis on uniX)	<ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/asax/>
Bastille Linux	<http://www.bastille-linux.org/>
Blowfish Encryption Algorithm	<http://www.schneier.com/blowfish.html>
clog	<ftp://ftp.cerias.purdue.edu/pub/tools/unix/logutils/clog/>
courtney	<ftp://ftp.cert.dfn.de/pub/tools/audit/courtney/>
EagleX	<http://www.engagesecurity.com/>
enhanced portmap/rpcbind	<ftp://ftp.porcupine.org/pub/security/>
gabriel	<ftp://ftp.cert.dfn.de/pub/tools/audit/gabriel/>

HenWen	< http://www.Snort.org/dl/contrib/front_ends/henwen/ >
Hisecweb.inf	< http://support.microsoft.com/support/misc/kblookup.asp?id=Q316347 >
IIS Lockdown Wizard	< http://www.microsoft.com/downloads/details.aspx?displaylang=en&FamilyID=DDE9EFC0-BB30-47EB-9A61-FD755D23CDEC >
Kiwi Secure Tunnel Tool	< http://www.kiwisyslog.com/ >
Kiwi Syslog Daemon Service	< http://www.kiwisyslog.com/ >
klaxon	< ftp://ftp.cerias.purdue.edu/pub/tools/unix/logutils/klaxon/ >
LANguard Network Security Scanner	< http://www.gfi.com/downloads/downloads.asp?pid=8&lid=1 >
libol 3.10	< http://www.balabit.com/products/syslog-ng/upgrades.bbq >
logdaemon	< http://www.cert.org/security-improvement/implementations/i041.11.html >
loginlog	< ftp://ftp.cerias.purdue.edu/pub/tools/unix/logutils/loginlog/ >
logsurfer	< http://www.cert.org/security-improvement/implementations/i042.02.html >
Isof (LiSt Open Files)	< http://www.cert.org/security-improvement/implementations/i042.05.html >
Microsoft Baseline Security Analyzer	< http://www.microsoft.com/technet/treeview/default.asp?url=/technet/security/tools/Tools/mbsahome.asp >
MySQL	< http://www.mysql.com/ >
MS SQL Server	< http://www.microsoft.com/sql/ >
Nessus Vulnerability Scanner	< http://www.nessus.org >
NetTime	< http://nettime.sourceforge.net >

nftswatch	< ftp://ftp.cerias.purdue.edu/pub/tools/unix/netutils/nftswatch/ >
nmap	< http://www.insecure.org/nmap/ >
NTsyslog	< http://sabernet.home.comcast.net/software/ntsyslog.html > < http://ntsyslog.sourceforge.net/ >
Oracle	< http://www.oracle.com >
pidentd	< ftp://ftp.cert.dfn.de/pub/tools/audit/pidentd/ >
PostgreSQL	< http://www.postgresql.org/ >
PureSecure	< http://www.demarc.com >
RazorBack	< http://www.intersectalliance.com/projects/RazorBack/index.html >
rfingerd	< ftp://ftp.cerias.purdue.edu/pub/tools/unix/daemons/rfingerd/ >
Sam Spade Desktop	< http://www.samspace.org >
showid	< ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/showid/ >
SnortCenter	< http://users.pandora.de/larc/index.html >
SnortFE	< http://security.scalzitti.org >
SnortSam	< http://www.Snortsam.net/index.html >
Software Update Services (SUS)	< http://www.microsoft.com/windowsserversystem/sus/default.msp >
swatch	< http://www.cert.org/security-improvement/implementations/i042.01.html >
syslog-ng	< http://www.balabit.com/products/syslog-ng/upgrades.bbq >
tcpdump	< http://www.cert.org/security-improvement/implementations/i042.13.html >
tcp wrapper	< http://www.cert.org/security-improvement/implementations/i041.07.html >

Tiny Personal Firewall	<http://download.com.com/3302-2092_4-6313778.html?pn=1&fb=2>
tklogger	<ftp://ftp.eng.auburn.edu/pub/doug/tklogger>
Tripwire	<http://www.tripwire.com>
watcher	<ftp://ftp.cerias.purdue.edu/pub/tools/unix/sysutils/watcher/>

References

URLs are valid as of the publication date of this document.

- [Bird 03]** Bird, T. *Syslog Attack Signatures*.
<<http://www.counterpane.com/syslog-attack-sigs.pdf>> (2003).
- [Brandolini 01]** Brandolini, S and Green, D. *The Windows Time Service*.
<<http://www.microsoft.com/windows2000/techinfo/howitworks/security/wintimeserv.asp>> (2001).
- [Bryce 01]** Bryce, R. *Gartner Recommends Against Microsoft IIS*.
<<http://www.eweek.com/article2/0,4149,1240915,00.asp>> (2001).
- [Burnett 03]** Burnett, M. *Forensic Log Parsing with Microsoft's Log Parser*.
<<http://www.securityfocus.com/infocus/1712>> (2003).
- [Campi 03]** Campi, N. *Syslog-ng FAQ*. <<http://www.campin.net/syslog-ng/faq.html>> (2003).
- [Caswell 03]** Caswell, B., Beale, J., Foster, J., and Faircloth, J. (Eds.) *Snort 2.0 Intrusion Detection*. Rockland, MA: Syngress, 2003.
- [CERT 03a]** CERT Coordination Center. *Identify Data That Characterize Systems and Aid in Detecting Signs of Suspicious Behavior*.
<<http://www.cert.org/security-improvement/practices/p091.html>> (2003).
- [CERT 03b]** CERT Coordination Center. *Responding to Intrusions*.
<<http://www.cert.org/security-improvement/modules/m06.html>> (2003).
- [Kistler 03]** Kistler, U. *Snort IDScenter 1.1 Manual*.
<<http://www.engagesecurity.com/docs/idscenter/>> (2003).
- [LinuxGuruz 03]** LinuxGuruz. *Linux iptables HOWTO*. <<http://www.linuxguruz.com/iptables/howto/iptables-HOWTO.html>> (2003).

- [Microsoft 03a]** Microsoft. *Deploying Microsoft Software Update Services*. <http://www.microsoft.com/windows2000/docs/SUS_Deployguide_sp1.doc> (2003).
- [Microsoft 03b]** Microsoft. *Secure Internet Information Services 5 Checklist*. <<http://www.microsoft.com/technet/treeview/default.asp?url=/technet/security/tools/chklist/iis5chk.asp>> (2003).
- [Microsoft 03c]** Microsoft. *Securing Windows 2000 Server*. <<http://www.microsoft.com/technet/treeview/default.asp?url=/technet/security/prodtech/windows/secwin2k/default.asp>> (2003).
- [Mills 91]** Mills, D. *Protocol Conformance Statement*. <<http://www.sunsite.ualberta.ca/Documentation/Misc/ntp-4.0.99a/biblio.htm>> (2003).
- [NSA 03a]** National Security Agency. *NSA Guide to the Secure Configuration and Administration of Microsoft Internet Information Services 5.0*. <<http://www.nsa.gov/snac/win2k/guides/w2k-14.pdf>> (2003).
- [NSA 03b]** National Security Agency. *NSA Guide to Securing Microsoft Windows 2000 File and Disk Resources* <<http://www.nsa.gov/snac>> (2003).
- [NSA 03c]** National Security Agency. *NSA Guide to Securing Microsoft Windows 2000 Group Policy*. <<http://www.nsa.gov/snac/win2k/guides/w2k-2.pdf>> (2003).
- [NSA 03d]** National Security Agency. *NSA Guide to Securing Microsoft Windows 2000 Group Policy: Security Configuration Tool Set*. <<http://www.nsa.gov/snac/win2k/guides/w2k-3.pdf>> (2003).
- [O'Reilly 02]** O'Reilly. *Building Secure Servers with Linux*. <<http://www.oreilly.com/catalog/bssrvrlnx/chapter/ch10.pdf>> (2002).
- [Pickel 00]** Pickel, J. and Danyliw, R. *Enabling Automated Detection of Security Events That Affect Multiple Administrative Domains*. <<http://www.incident.org/thesis/book1.html>> (2000).
- [Red Hat 03]** Red Hat, Inc. *Red Hat Linux 8.0: The Official Red Hat Linux Reference Guide*. <<https://www.redhat.com/docs/manuals/linux/RHL-9-Manual/ref-guide/ch-tripwire.html>> (2003).
- [SANS 03]** The SANS Institute. *The Twenty Most Critical Internet Security*

Vulnerabilities. <<http://www.sans.org/top20/>> (2003).

[SSI 03]

Service Strategies, Inc. *Glossary of Messaging and Network Security Terms*. <<http://www.ssimail.com/Glossary.htm>> (2003).

[Vacca 02]

Vacca, J. *Computer Forensics—Computer Crime Scene Investigation*. Hingham, MA: Charles River Media, 2002.

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